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Two Ways of Giving Instructions

A GRUFF "CALL DOWN" ACCOMPLISHES LESS THAN AN EXPLANATION.

Difficulties of a Mechanical Engineer

By G. H. Leaverton

SYNOPSIS—After being engaged to prepare plans for needed improvement the superintendent is found to be hostile and the president looks on. Uneconomical conditions were finally eliminated under the direction of a new superintendent.

That the value of a power plant decreases and the operating and maintenance charges increase very rapidly through the lack of coöperation of the several heads of departments of a concern, is well known to mechanical, consulting and operating engineers.

The mechanical engineer, by virtue of his technical training and general experience, is capable of intelligently outlining and inaugurating economical methods and installing the proper equipment. As an illustration of the fallacy of placing technical power-plant matters in the hands of nontechnically experienced men, as well as the lack of coöperation between the different departments, an experience of the writer is given herewith.

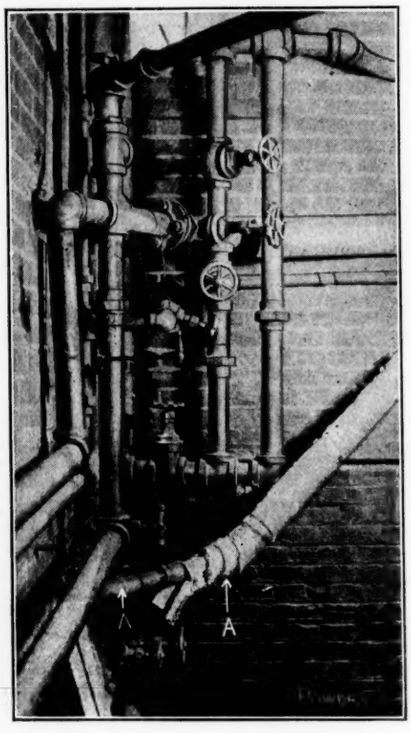

Fig. 1. Piping Where Elbow Wore Rapidly

Hostile Superintendent

Shortly after entering the employ of a certain concern as mechanical engineer, I was instructed by the president to prepare a report on one of their several power plants which he thought could be greatly improved and more economically operated.

Plans were prepared and approved by the vice-president, and upon his recommendation the president ordered the superintendent to proceed with the alterations and new installations. The superintendent after looking them over went to the president, who hardly knew a condenser from a feed-water heater, and proceeded to find fault with all of the contemplated alterations. The superintendent would not coöperate with the engineering office and the president would not make him, so the improvements were held up until the superintendent resigned, and his successor, a man with technical training, saw the need of such improvements and proceeded to install them in accordance with the plans already prepared.

Heating the Feed Water

The plant consisted of two 500-hp. condensing engines, one of which was in continuous operation, and 700 hp. in boilers. There were three boiler-feed pumps, two being piped to small individual tanks, which acted as open feed-water heaters.

The feed pumps, vacuum pumps and other auxiliaries exhausted into these tanks, thereby heating the feed water. The pumps were on a level with the tanks, and frequently got steam bound, which necessitated cooling the water before it could be handled. Then, to further heat it after leaving the feed pumps, it was pumped through a home-made closed heater.

The large engines were steam jacketed and the steam was originally trapped, but the station engineer had bypassed the trap and run the jacketing steam to the closed heater, thence to a storm-water sewer, without a trap in the line. Several drip lines from the main steam header were also run to this heater without being trapped. As the steam had an unrestricted passage through the jackets and the heater to the sewer, vapor was caused to arise from various sewer inlets. To prevent this evil a jet condenser arrangement was constructed to condense the steam.

Pipe *A*, Fig. 1, shows the line conducting the jacket steam to the heater. Owing to the high velocity attained, the 45-deg. elbow kept continually cutting through and had to be renewed.

New Heater

The new arrangement provided for a standard make of open feed-water heater of ample proportions, placed above the feed pumps at a sufficient height to insure a constant head of water, thereby preventing them from getting steam bound. All of the high-pressure drips, jacket steam and the like, all trapped, were discharged into the new heater. There was also a dynamo engine, operating at night only, which had been exhausting to the atmosphere; this exhaust was also taken to the heater.

In Fig. 2 are shown the tanks at the feed pumps and in Fig. 3 the numerous pipe lines in the station. Steam or water pipe was duplicated two or three times to no purpose whatever. If the engineer wanted to shut off any particular line or unit he had to follow it along its numerous and devious repetitions to find which valves to operate. The slovenly and careless method of running piping, shown so clearly in Fig. 3, is only an average sample of the care that this whole station received. All of this was done away with and a simple and systematic layout of both steam and water piping was put in.

Blowing Down Boilers

Another great source of waste was in the method of blowing down the boilers. It was the custom to blow down six times in 24 hr. A simple calculation, based on the amount blown down each time and using a lower heat rating of the coal than was actually obtained, showed that it took approximately 500 tons of coal per year to heat this water blown out. This could easily have been cut down to 200 tons per year, as upon inquiry among other firms using identically the same feed water it was only necessary to blow down twice in 24 hours.

This was objected to by the superintendent, who claimed that the boilers would scale badly, in spite of all the proofs offered to the contrary from other reliable firms operating under similar conditions.

The water normally is not a scaling water, yet they were using a compound at the rate of 1 lb. per 10,000 gal. when ½ lb. was ample. The boilers had a single tee-cock in the blowoff line. This I considered positively dangerous to both the boiler and the employees. I have seen the fireman take a 2-ft. lever handle and open these cocks as quickly as possible, little realizing the enormous water-hammer on the piping that was produced. I often wonder why an elbow or other part did not give way. The superintendent again objected to any change here as a needless expense, claiming that they never had any accidents and he "guessed" they never would.

The total cost of all the alterations and improvements did not exceed $2500, and the station could have saved this amount in reduced expense in about one year.

The other two plants of the concern were in far better condition than the one in question, and showed the character and ability of their respective engineers, who were not only willing, but anxious to have the improvements made, and they coöperated with the engineering office as far as was possible.

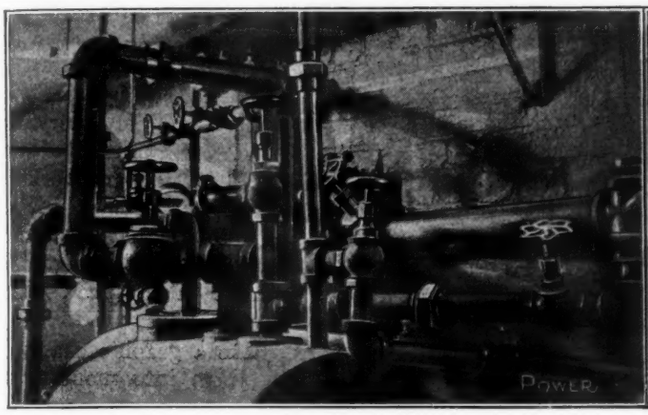

Fig. 2. Piping above Tank

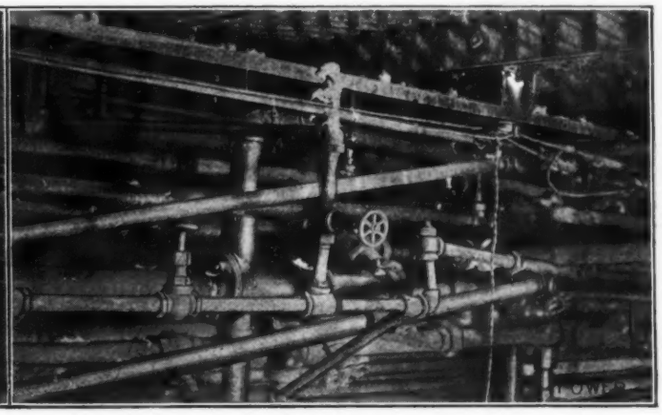

Fig. 3. A Tangle of Piping

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"Keeping Tab" in Industrial Plants*

By P. Lundeby

SYNOPSIS—Some suggestions as to the best manner of recording facts and data concerning power-plant operation which should prove valuable to those desiring to establish a system of record keeping.

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In operating engineering the former goodly amount of guesswork, as to results obtained, is giving way to reliable data arrived at by a thorough system of "keeping tab" on every phase of operation.

The chief engineer, being given the responsibility and power to act, should gather, from the first day he assumes charge, accurate information about all machinery and apparatus under his charge and file it for future use. He should aim at definite and accurate data for two purposes; one to determine without delay matters pertaining to the maintenance, operation and efficiency of any machine when required, the other to determine the cost per unit of steam, electricity, air, water, etc.

The first will include all principal dimensions of the boilers, chimney, engines, generators, pumps and all working machinery, also the sizes and style of all packing. Valves, correctly set, should be trammeled, and the correct clearance at both ends of cylinders recorded.

On installing new machinery, the results of the initial trials should be recorded, and filed for reference. Duplicate copies of these results should also be made. It is of value to know the conditions under which a boiler, engine, pump or other apparatus worked when new, for comparison with later tests and trials. The engineer can also increase the efficiency of the men and thereby the plant, in establishing a system of daily records kept by the men in charge of the various departments, dealing with every important factor relating to the equipment they are handling.

These data are essential as the very basis on which to arrive at the real results obtained. Equally important is the continuous record of the feed-water temperature. An inserted thermometer in the feed line will make this easy. An intelligent chief fireman, given the necessary devices, will usually interest himself in securing all this information, as it adds to the feeling of responsibility and perhaps dignity. He should record at in-

*Read before the second annual meeting of the Institute of Operating Engineers, New York City, Sept. 6 and 7, 1912.

tervals, the temperature of the flue gases as well as readings of the draft gage, the time each boiler has been in operation, when cleaned and inspected, and any defects, leaks, etc., discovered. The periodical visit of the boiler inspector should be welcomed and of interest and benefit as well to the chief fireman as to the chief engineer, and his advice considered by both.

The watch engineer should fill out a form, giving all necessary information about the conditions under which the machinery under his care is working. Here is where recording instruments are valuable. Knowing that there will be a curve to tell the tale, will tend to keeping all the equipment well cared for. Recording instruments are especially valuable where operation is continuous day and night. Where a number of different departments use water, steam and electricity for manufacturing generally metering the consumption of each department will pay.

The "keeping tab" must be progressive. Beginning in the boiler room, detailed information should be gathered from the various departments, to which the output of the power plant is being distributed.

To the cost per boiler horsepower-hour must be added the cost of operation of the boiler room, materials, repairs and maintenance, the proportional amount of administration expenses and interest, as well as a fair percentage of depreciation of buildings and equipment. By intelligent use of the indicator, the consumption of steam of the various engines and generators will be arrived at, and fairly accurate constants determined to simplify the daily calculation of the amount of steam used per unit of the output as kilowatt-hours, tons of refrigeration and cubic feet of air and water per brake horsepower-hour. To these items must be added the correct proportion of the several expense burdens.

Record keeping will be made easier by using printed blanks for all purposes, all aiming at the finished result at the end of the month, when a resumé of the daily log, in concise form, should be submitted to the manager's office. There is a daily education in "keeping tab," the value of which has rarely been appreciated by employer or operator. The latter will find that the more means and devices he equips the plant with for this purpose, the more he realizes how little he really knew before, and how throwing light on one subject will usually lead to the discovery of another hitherto unnoticed source of waste.

All the monthly record sheets should be filed from month to month and year to year for comparison. In plants where many electric motors are used, readings should be taken at intervals, or when undue sparking and heating occurs, to see that they do not carry depredatory overloads. A water meter furnishes an excellent check on the proper working of a pump, its capacity when installed being known. To check the meter on the feed-water line some means should be provided. If the pumps get the water from a tank, the volume being known, readings of the meter and fall of the water level in the tank may be taken simultaneously for comparison. If inaccuracy exists the amount it represents should be added or deducted from the daily meter readings.

To determine the efficiency of condensing plants and cooling towers, temperatures should be taken of water entering and leaving the towers, preferably by providing the pipes with inserted thermometers. Often an undue amount of waste is taking place here, and considerable economy may be obtained by proper investigation and experiments. Where scale-forming water is used, piping must not be allowed to scale too heavily, as this will soon reduce the capacity and increase the friction head on the pumps. Another item often unheeded is the wasted exhaust-steam from the pumps, small engines, traps, etc., which might be profitably used in heating feed water. Record keeping reveals all these losses. The top of the smoke-stack, while not a CO_2 recorder, affords a persistent indicator of the management of the fires.

In large industrial plants having a machine shop for making repairs and changes, a technical assistant, as draftsman, if added to the force, should be entrusted with the keeping of the operation records and the supervision of all recording or indicating devices. Plants of this kind covering large areas often have a network of underground piping, an accurate plan of which is essential. It should be kept uptodate by drawing in new lines and eliminating old ones, new prints being made when any marked alterations have taken place. This will save much trouble and labor.

It is worth the expense to make a graphic chart, dividing the year into quarters, these into months and these again into days, showing a continuous curve of fuel consumption, evaporation of water and output of products. It tells an interesting story at the end of the year. These may be traced and prints made for the engineers and manager's office.

A wide-awake engineer, knowing every detail about his plant, seeing its weaknesses and possibilities, and daily studying and learning new facts and features of its various branches will prove himself to the manager, as the best consulting engineer he could employ.

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River Water Used Eight Times

Power can be developed upon many surface streams and applied to the recovery of the water of the streams after it has sunk into the earth in the lower valley lands.

An instance of this character, according to the United States Geological Survey, is to be found along Santa Ana River in southern California. A part of the water is stored in a reservoir in the San Bernardino Mountains and the flow of the stream is thereby regulated. After it escapes from the reservoir it is diverted through a power plant and electric power is generated. Below this power plant it is rediverted and passed through a second power plant. Below this it is all distributed and used by cities or for irrigation about Redlands and Highlands.

The waters that return from the irrigation are recovered in springs and flowing wells and by pumping plants, a part of the power developed higher up on the stream being used for the pumping. This recovered water is used for irrigation about San Bernardino and Riverside. A part of it reappears in the river above Riverside Narrows, where it is again taken out into a power ditch whose waters are returned to the river above Corona. A few miles below it is picked up by canals and distributed to the orange and deciduous groves about Anaheim and Santa Ana. The part of it that returns there, by irrigation, to the ground water is once more recovered by the pumping plants and flowing wells west of Santa Ana.

A single drop of water in its progress from the mountains to the sea, a distance of only 100 miles, may thus be used as many as eight times.

Size, Capacity and Power Required for Centrifugal Fans

By Frank B. Gilbert, Jr.

SYNOPSIS—By the use of diagrams and without calculation the size of fan required to handle a given volume of air per minute against a given pressure may be determined, and the power required to drive it found. The charts also give the capacity when other factors are known.

The accompanying diagrams are intended as a convenient means for obtaining graphically the relations between friction to be overcome in air ducts, size and speed of centrifugal-fan wheels, and the horsepower required to drive them.

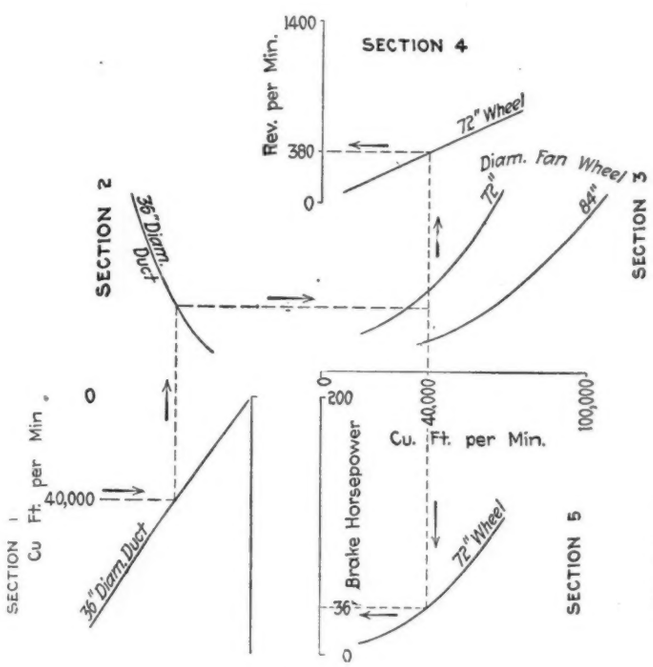


FIG. 1

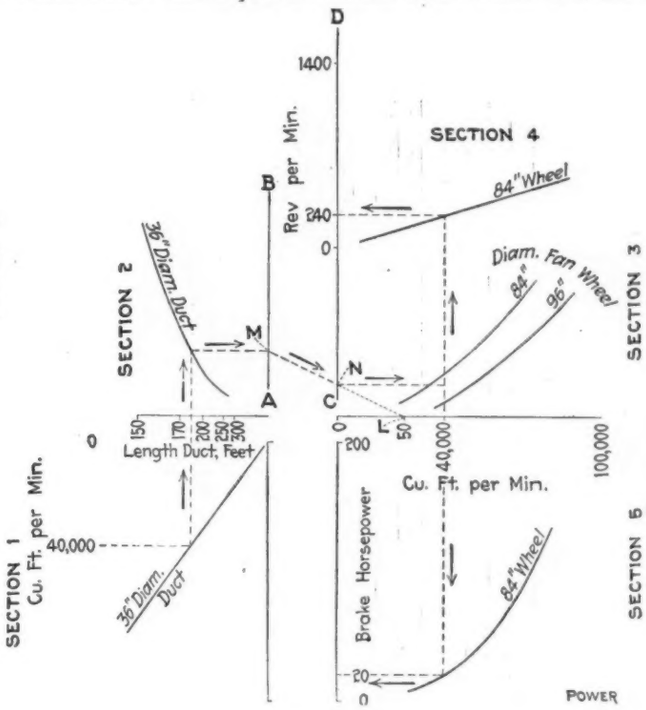


FIG. 2

In some instances the diagrams may not entirely replace mathematical calculations to determine a fan which is to meet specified requirements, but even then are advantageous to check the calculations.

The results obtained from the diagrams are applicable only to the average type of fan now on the market and will vary slightly with differences in various manufacturers' constructive details.

The friction losses used in plotting the diagrams compare favorably with actual tests made by the author on long circular iron ducts.

The following example illustrates the use of the diagrams:

To transmit 40,000 cu.ft. of air per minute through a duct 36 in. in diameter and 100 ft. long, what size, speed and horsepower of fan are necessary?

For clearness the problem is shown in Fig. 1, isolated from the large diagram.

In the diagram for steel-plate fans in Section 1 is found a scale of fan capacities and curves for different diameters of ducts. Beginning at the 40,000 division of the capacity scale a line is traced horizontally to the right until it intersects the curve for 36-in diameter duct. From this point a path is followed upward to the 36-in. diameter duct curve in Section 2 and thence horizontally into Section 3, stopping directly over the 40,000 mark of the scale showing cubic feet of air per minute in this section.

The position thus reached is found to be between curves for fan wheels 72 and 84 in. in diameter. The 84-in. fan would deliver the required amount of air under free discharge but would not maintain enough pressure to overcome friction of the specified duct. A 72-in. fan would deliver a slight excess of pressure.

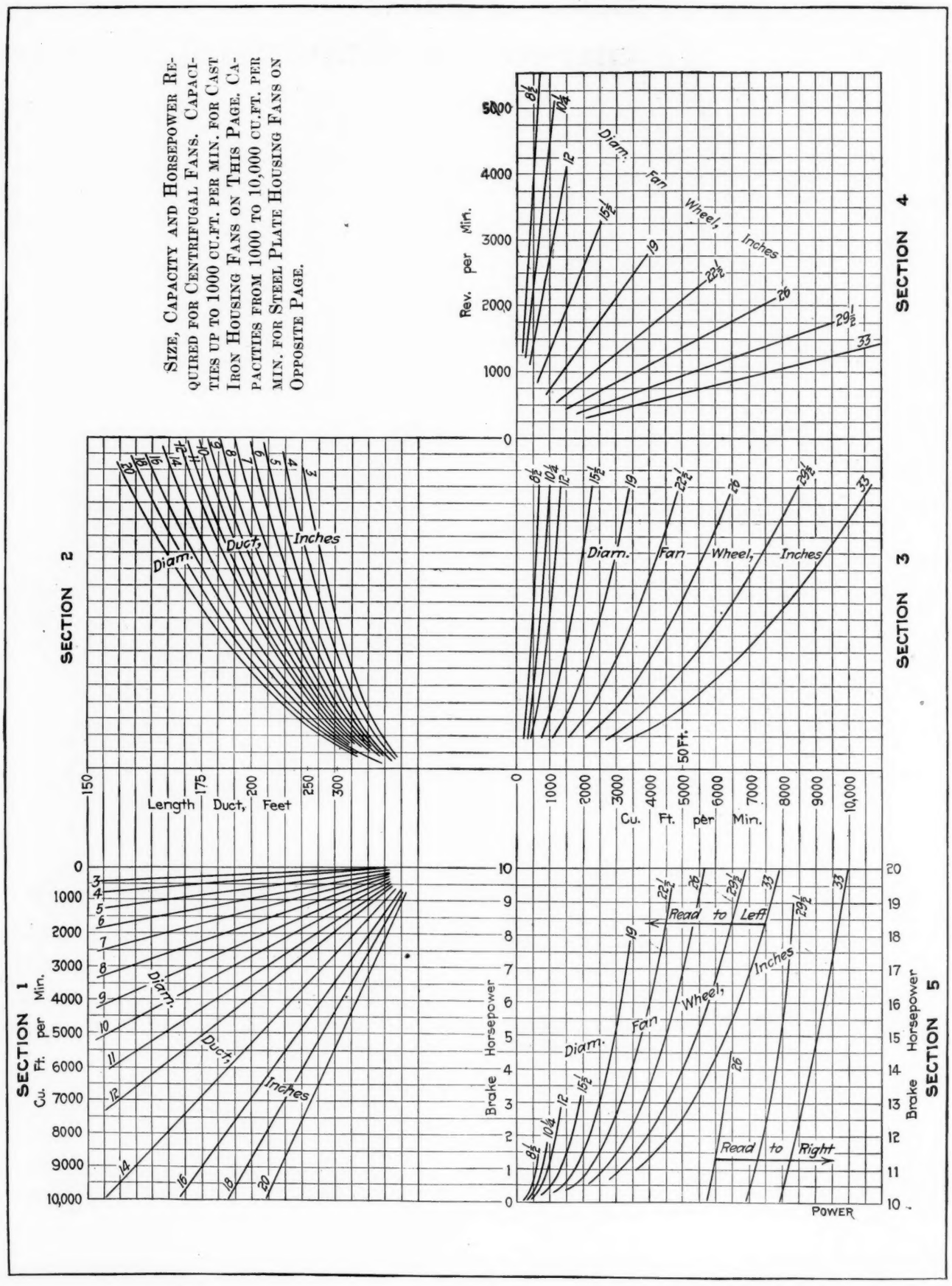
Selecting, then, a 72-in. fan and tracing vertically upward from the 40,000 cu.ft. per min. graduation into Section 4, another 72-in. fan wheel curve is intersected at a point opposite the speed of 380 r.p.m.

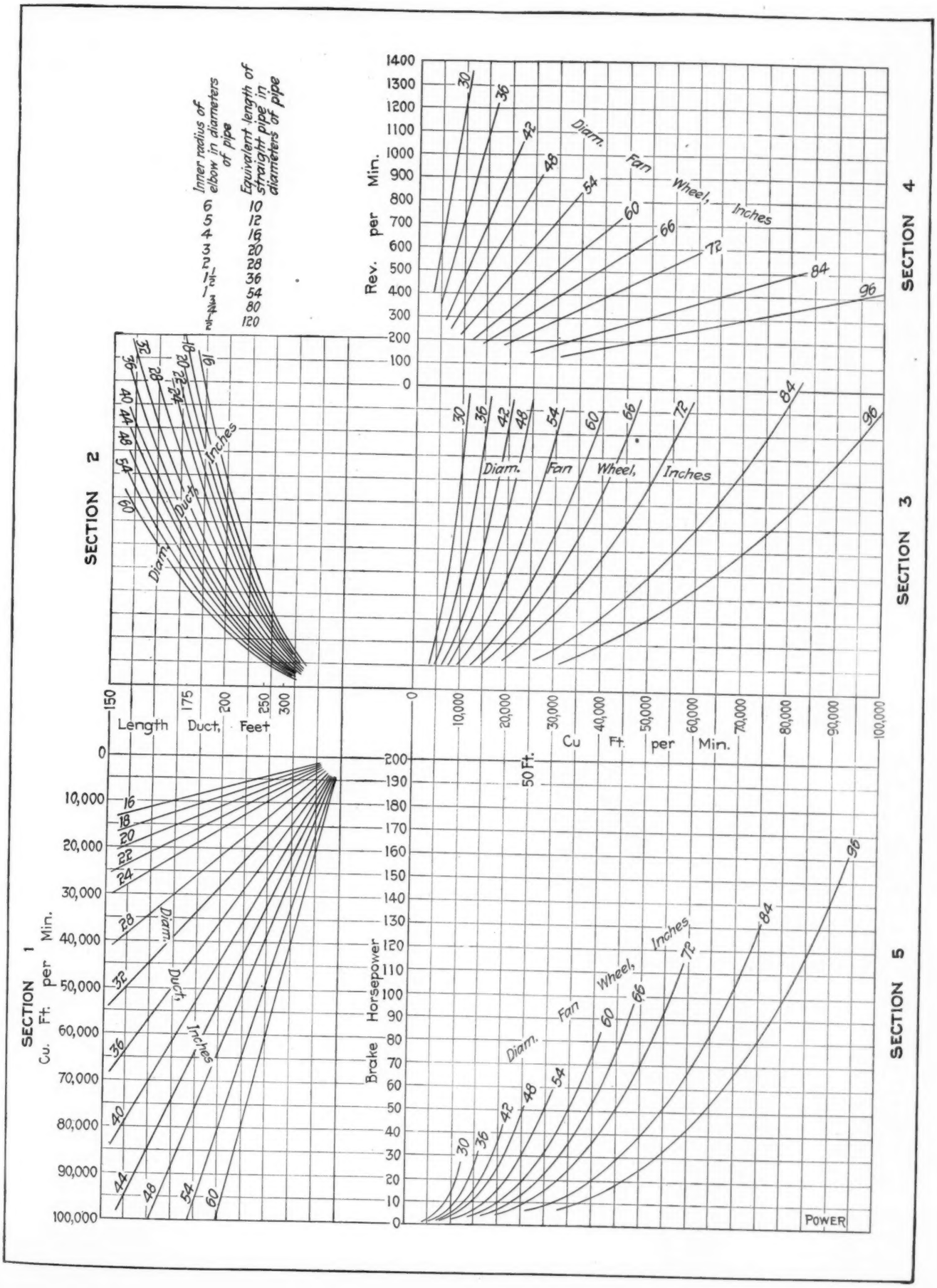
Returning to the vertical line passing through the 40,000 mark and following downward into Section 5 until the 72-in. fan curve is met, and then to the left, 36 hp. is found to be required to operate the fan.

In the solution of the above problem no use was made of the scale in Section 2, entitled "Length of Duct," the 50-ft. division of which appears in Section 3. This is because the diagrams are based on friction losses for ducts 100 ft. long and with this length, as in the problem just solved, no account is made of duct length.

If the duct had been 50 ft. long the problem would have been solved, as shown in Fig. 2, which is identical

SIZE, CAPACITY AND HORSEPOWER REQUIRED FOR CENTRIFUGAL FANS. CAPACITIES UP TO 1000 CU.FT. PER MIN. FOR CAST IRON HOUSING FANS ON THIS PAGE. CAPACITIES FROM 1000 TO 10,000 CU.FT. PER MIN. FOR STEEL PLATE HOUSING FANS ON OPPOSITE PAGE.




SECTION 1
Cu. Ft. per Min.
Length Duct, Feet
Diam. Duct, Inches
SECTION 2
Inner radius of elbow in diameters of pipe
Equivalent length of straight pipe in diameters of pipe
SECTION 3
Rev. per Min.
Diam. Fan Wheel, Inches
SECTION 4
Brake Horsepower
50 Ft.
Cu Ft. per Min.
Diam. Fan Wheel, Inches
SECTION 5
POWER

with the solution in Fig. 1 except that upon reaching line *AB* at *M* (Fig. 2) instead of continuing horizontally to line *CD*, a straight-edge is placed to coincide with points *M* and *L*, thereby determining point *N* in line *CD*. Continuing horizontally from point *N* as was done in Fig. 1, an 84-in. fan running at 240 r.p.m. and requiring 20 hp. is obtained.

Corrections should be made for friction losses, due to elbows in the air duct, according to the table of equivalent lengths of straight pipe on page 75.

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Development in Marine Condensers

SYNOPSIS—Main factors controlling heat exchange, the steam and water paths and some typical condenser data and performances.

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Before the Institute of Engineers and Shipbuilders, in Scotland, William Weir read an extended paper on the "Development in Auxiliary Units between Exhaust Pipe and Boiler." The chain of auxiliary machinery involved in the treatment was: condenser, circulating pump, air pump, feed-heating apparatus, feed-pumping apparatus and feed makeup apparatus. As a preliminary the main principles of the respective apparatus were recorded and the approximate dates annexed in each case. The apparatus listed above was then discussed

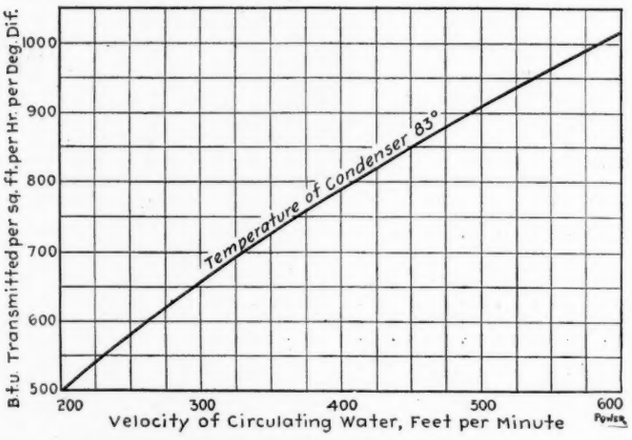


FIG. 1. TRANSMISSION RATE DIAGRAM

at some length under distinctive heads. The sections on pumps were of exceptional interest, but in the present review only that part of the paper relating to the condenser proper will be considered.

Viewed broadly, a surface condenser is an apparatus wherein a heat exchange takes places between exhaust steam and water. The main factors controlling this exchange are: The temperature difference between the steam and the water; velocity of steam; velocity of water; presence of noncondensable gases in the steam, and to a lesser extent, the mean temperature of the steam and water.

The conditions to which a well designed condenser for marine use and for any specific vacuum and sea temperature should conform are: Minimum weight and space, minimum power absorbed by circulating pump, minimum cooling of condensed water, minimum variation of pressure on the steam side.

In a condenser in which the water passes through a number of small tubes inside a containing vessel to which the steam is introduced, the steam path must be such that the maximum velocity is attainable with the

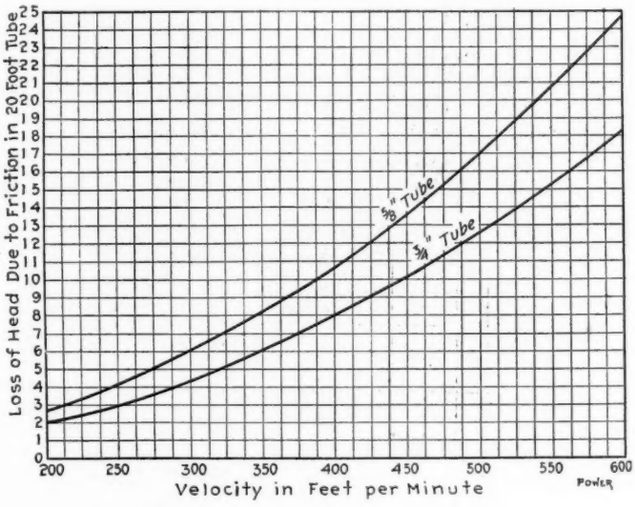


FIG. 2. FRICTIONAL HEAD DIAGRAM

minimum loss of head. Obviously then the path must be, as nearly as possible, straight, and the velocity must be maintained constant in value. The first condition precludes the use of baffle-plates, the second necessitates a varying cross-sectional area, which should vary in proportion to the condensation. The only other factor directly influencing the contour of the steam path is the quantity of noncondensable gases present. Maximum efficiency requires that this quantity should be kept at a minimum. This constitutes the function of the air pump. It is to be noted that the steam path has been considered without reference to its condition—condensed or noncondensed. Where one pump is used both as

TABLE 2. CONDENSER WEIGHTS.

Class of Installation	Vacuum in inches	Sea Temperature, Deg. F.	Material of Shell	Type of Condenser	Weight per hp. in lb.	Engines	Assumed Steam consumption per hp. in lb.
Cargo Steamer 3000 hp	23	85	Cast Iron	Old Rectangular on engines	8.3	Reciprocating	15
Cargo Steamer 3000 hp	23	85	Steel	Circular	7.5	Reciprocating	15
Cargo Steamer 3000 hp	25	85	Steel	"Uniflux"	3.35	Reciprocating	15
Cross-Channel Boat	28.5	55	Steel	"Uniflux"	3.5	Turbine	14
Atlantic Liner	28.5	60	Steel	"Uniflux"	4.67	Turbine	14
Destroyer (1900)	26.5	55	Sheet Brass	Oval	2.7	Turbine	16
Destroyer (1912)	28	55	Steel	"Uniflux"	2.1	Turbine	14
Cruiser (1907)	27	55	Cast G.M.	Circular	4.4	Turbine	15
Cruiser (1912)	28.25	55	Steel	"Uniflux"	3.4	Turbine	14
Battleship (1906)	28.5	55	Cast G.M.	Circular	6.06	Turbine	14½
Battleship (1912)	28.5	55	Steel	"Uniflux"	4.09	Turbine	13½
Distilling Condensers	18	80	Steel	"Uniflux"	2.2	Turbine	15

TABLE 1. TYPICAL "UNIFLUX" CONDENSER DATA AND PERFORMANCES

Installation No.	Class of Installation.	Type of Engine	Horse-power.	Steam Consumption lb. per hr.	Cooling Surface, sq.ft.	Condensation rate in lb. sq.ft.	Guarant. Vacuum 30-in. Bar.	Sea Temperature Deg. F.	Actual Vacuum 30-in. Bar	Sea Temperature Deg.F.	Temp. Circulating Water Outlet	Hot-well Temperature Deg. F.	Diff. Deg. F. from theoretical Outlet Temp.	Diff. Deg. F. from theoretical Hot-well Temp.	Tubes Diameter Thickness Length	No. of Flows	Type of Air Pump
1	Small Mail Steamer	Reciprocating	5,800	87,000	3,282	26.5	25.5	55	26.8	44	110	110	6	6	¾" 18" W.G. 7' 8¼" overall	3	Engine-driven Edwards
2	Mediterranean Mail Steamer	Reciprocating	12,000	180,000	8,000	22.5	26	60	27.7	72	99	104	6	1	¾" 18" W.G. 7' 6" overall	3	"
3	English Channel Steamer	Turbine	12,000	180,000	8,636	20.8	28.5	55	28.95	49	69	69	9.5	9.5	¾" 18" W.G. 10' overall	2	Independent "Dual"
4	Intermediate Atlantic Liner	Reciprocating	12,000	174,000	8,440	20.6	27	60	27.2	53	103	98	9	14	¾" 18" W.G. 10' overall	2	"
5	Fast Cruiser	Turbine	22,000	340,000	16,820	20.25	28.25	55	28.8	54	75	78	8	5	¾" 18" W.G. 7' 6" overall	2	"
6	Battleship	Turbine	27,000	418,500	21,600	19.375	28.5	55	28.85	57	76	76	5	5	¾" 18" W.G. 8' overall	2	"
7	Destroyer	Turbine	17,000	240,000	9,000	26.7	28	55	28.55	45	78	78	11	11	¾" 18" W.G. 15' overall	1	"
8	A London Power Station	Turbine	2,000K.W	28,800	3,000	9.6	26	75	28.1	75	95	95	3	3	¾" 18" W.G. 6' 2¼" overall	4	"
9	Large Cargo Steamer	Reciprocating	5,300	80,000	4,400	18	25	85	{ 27.3 26.75	44 84	105 106	111 106	6 11	0 11	¾" 18" W.G. 7' 6" overall	3	Engine-driven "Dual"
10	Fast Yacht	Turbine	2,500	46,000	1,300	35.4	27	55	27.3	54	86	101	10	9	¾" 18" W.G. 7' 6" overall	2	Independent "Dual"
11	Turbo-Generator Condenser	.....	.....	15,000	300	50	.....	.....	23½	60	111	120	.....	.....	¾" 18" W.G. 5' overall	4	"Monotype"

air pump and condensed-water pump, the path of the steam will necessarily be identical with that of the condensed water. Where separate pumps are used, however, it will be possible to treat the vapor and water differently, and to give them different paths. Whether it will be advisable to do so or not will depend on whether the transmission rate is affected by the state—liquid or gaseous—of the material on the steam side of the tubes, always remembering that equal velocities are assumed.

Practical considerations which limit the closeness of pitch of tubes, prevent the attainment of high velocities with water except when held in suspension in a gaseous medium, so that in a condenser of homogeneous construction, sumberged tubes are not compatible with the highest overall efficiency.

FIG. 3. REPRESENTATIVE TUBE-PLATE DIAGRAMS

As there is no change in volume of the water, and as its heat-transferring value, per unit temperature difference, is not appreciably changed during its course, its velocity, and hence the cross-sectional area of its path, should be uniform. The velocity chosen will depend on the mode of variation of the heat-transmission rate with velocity and on the permissible expenditure in obtaining that velocity. In considering the correct quantity of circulating water to use, it must be borne in mind that the quantity of water chosen will necessarily define its outlet temperature. The actual quantity will then be a matter of compromise between expenditure of pumping it, and its reaction on the length of water path required before the outlet temperature which it entails is attained.

The variation of heat-transmission rate with velocity of water flow is shown in Fig. 1, and the variation of

frictional head with velocity (for the size of tube commonly used) is shown in Fig. 2. In Fig. 1 it must not be assumed that the rates indicated are in every sense absolute. Under certain favorable conditions much higher rates have been attained. Reference to Table 1 will show a number of examples typical of modern practice for widely varying conditions, together with the performance of these installations.

One of the most interesting installations is No. 8, where economy in circulating water was necessary, and No. 9 is also exceptional as showing the performance of one of the installations with engine-driven "Dual" air pumps. No. 10 shows the overload performance on a turbine yacht where light weight of condensing plant was of great importance. In the case of the reciprocating-engine installations the vacua being carried are too high for economical running, but in every example the trials were made to show high degrees of vacua as being of interest in connection with the condenser performances apart from the main machinery.

No. 11 gives the results of a turbo-generator condenser. It may be noticed that the condensation rate is more than twice the average rate for the other installations. The cooling surface is only 300 sq.ft., and 15,000 lb. is condensed per hour.

Fig. 3 shows three typical tube-plate diagrams showing how uniform velocity is attained by contour of the shell and varying pitch of the tubes to suit special conditions of space.

Table 2 gives some interesting figures regarding the weight of condensers. Adhering to principles of design previously given, results in a type of condenser wherein no attempt whatever is made in achieve what has been termed sectional or compartmental drainage. In condensers possessing this feature, it is stated that the water of condensation is intercepted and removed to the hotwell as soon as it is formed—the basic idea being that the heat-transmission rate will thereby be improved and the hotwell temperature increased for a given vacuum. So far as experiments carried out by my firm have shown, no influence on the transmission rate by the interception of this water can be traced, while the claim for higher hotwell temperature is no longer supported.

The carrying out of this drainage feature includes the subdivision of the condenser by baffle-plates or collectors lying approximately parallel to the steam path, the angle of deflection presumably representing the extent to which gravity is to assist in the interception and removal of the condensed steam. Now the velocity of steam flow in a high-vacuum condenser might be taken as 500 ft. per sec., which represents 340 miles per hour, and this explains the fallacy of sectional drainage together with the impossibility of its practical achievement.

Another misconception with reference to condenser design concerns the use of what might be termed an inverted condenser, i.e., one in which the steam admission is at the bottom and the air extraction at the top. It has been stated that in such a condenser the steam will not readily rise, but, as a matter of fact, the steam will rise with the velocity already indicated, and if space considerations permitted such condensers, their performance would be as good as that of existing installations.

❋ ❋

New Theory of Condensation

SYNOPSIS—A thin film of air greatly reduces the heat transmission of a condenser tube. It is heavier than water vapor and to remove it most efficiently V-shaped passages are proposed.

❋

In the discussion of Mr. Weir's paper before the Institution of Engineers and Shipbuilders in Scotland on marine condensers, air pumps and feed heating plants, an excerpt from which is published on the preceding pages, D. B. Morison, of Hartlepool, presented a new theory on surface condensation.

Mr. Morison started off by establishing initial uniformity of exhaust distribution over the tubes throughout their whole length, and while maintaining such uniformity over the entire condensing surface, he maintained at the same time a continuity of flow through a passage of decreasing area from the exhaust inlet to the air outlet.

To lengthen the path of vapor flow in his original small condenser, Mr. Morison cut a wedge into three pieces and set one above the other. This small condenser he presented to the Armstrong College and Professor Weighton's experiments with it definitely established the correctness of the principles, as may be seen by reference to his paper before the Institution of Naval Architects in 1906, which was generally conceded to be the most valuable report on "Surface Condensing Efficiency" ever published.

By subsequent experience with large condensers, Mr. Morison found that the conditions enabled the wedge shape to be maintained linearly by light guide plates, which not only cheapened the construction and lessened the weight of large condensers, but in condensers of any size facilitated the employment of wedges of the proportions which had been found by exhaustive tests to give the highest efficiency.

If no air were present in condensers, the problem of surface condensation would be simplified as no air pump would be required, but in practice the crucial problem in the attainment of high vacuum is how best to treat the small quantity of air which normally enters the condenser with the steam, and at the same time to make provision for dealing with the much larger quantities which result from accidental and inevitable leakage into the vacuum system. As the result of much investigation over many years Mr. Morison submitted the following theory whereby a solution might, he thought, be found along the simple lines of elementary first principles.

In 1905, J. A. Smith of Australia carried out some valuable experiments to determine the effect of air on heat transmission through a condenser tube. He found broadly as follows: That the presence of air in quantities that might have been deemed insignificant may, in fact, become the factor limiting the efficiency of a whole steam plant. For instance, air equal in pressure to only $\frac{1}{20}$ in. by the mercury gage, will at 90 deg. F. reduce thermal transmission some 25 per cent., while $\frac{3}{20}$ in. will lower it about one-half.

The experiment further demonstrated that in a con-

denser dealing with steam at 90 deg. smothered with air at a partial pressure of 0.3 in. it would be found that the cooling surface would have to be 2¼ times greater than if dealing with airless water vapor at the same temperature.

In the experiments the feature of interest is the extraordinary degrading effect which a film of air of minute thinness has on the heat transmission of a condenser tube. At the other extreme it is known that when air is present in large quantities in a condenser the lowermost tubes may become so air drowned as to be quite incapable of condensing any appreciable vapor. It is also established that air is heavier than water vapor and consequently the natural tendency of aerated vapor is to fall and not to rise. This is of course apart from all considerations of velocity of entry. Therefore the first essentials for condenser efficiency are that the weight of air which always remains in a condenser shall be reduced to a minimum and shall be so disposed as to cause the least possible resistance to the transmission of heat through the tubes to the circulating water flowing through them. Another essential is that the air particles shall not eddy by taking an erratic course in any given horizontal plane or by making multiple appearances in any plane. In other words each air particle shall take its shortest route from the exhaust inlet to the air outlet and not linger on the way.

FIG. 1

FIG. 2

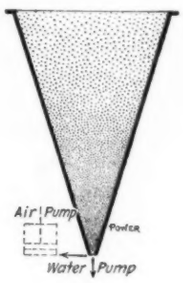


FIG. 3

Such a theory at once suggests that exhaust steam should enter a condenser as a uniformly moving column, the sectional area of the column being the plan area of the top row of tubes. Continue this plan area unchanged and the condenser becomes a rectangular box. If hypothetical stability is assumed the condenser becomes filled with an infinite number of horizontal superposed films, the top film containing the least amount of air and the bottom film the greatest.

The air contained in such a condenser is the sum of the particles in all the films and as the function of an air pump is to minimize the weight of air which is normally present in a condenser, it is obvious that the lowermost film which is the film richest in air should be preferentially and wholly withdrawn by the air pump and be followed by the entire withdrawal of the superposed film and so on.

What would actually happen, however, in such a rectangular box under such conditions would be that the air pump would break through several films locally and by withdrawing a charge less rich in air and therefore inferior would leave the bulk of the lowermost and densest film undisturbed.

Now suppose by some means or other the lowermost film were disposed vertically instead of horizontally; the air pump would then draw no multiple layers from unstable thinness but one layer from stable depth. The nearest practical approach to this requirement is a wedge section having a very narrow outlet, as in Figs. 2 and 3.

Again suppose another hypothetical condition, viz.: that there is no air in the condenser Fig. 1, and that the condensate is withdrawn by a water pump. Assume also that the frictional resistance of the vapor passing over the tubes is *nil;* were such conditions possible in practice, the vacuum and the temperature throughout the condenser would be constant. Fig. 2 represents the same condenser under conditions of ordinary practice, viz.: with air and air pump. Assume the air to be as shown and that the air density is proportionate to the depth of shading. Suppose such a condenser to be working under conditions of vacuum stability and with no eddying anywhere. The shading would then be lightest at the top and darkest at the bottom, the temperature would be highest at the top and lowest at the bottom and the charge of air withdrawn by the air pump at each stroke would be the densest the condenser contains. Now suppose in Fig. 3 the conditions are identical with those in Fig. 2 in every respect except that in Fig. 3 a lighter shading is maintained at the bottom of the condenser, say, for example, one corresponding to the shade in the middle of Fig. 2. It should be remembered that the quantity of air admitted with the exhaust is precisely the same in both Figs. 2 and 3, but the weight of air which always remains in the condenser in Fig. 3 is less than that which remains in Fig. 2 by the amount below the center line in Fig. 2.

The general technical effect which is thereby produced is that every single tube in the condenser has been relieved of a definite amount of air insulation and is therefore able to transmit more heat to the condensing water with the result that the final temperature of the condensing water increases, the condenser cools and the vacuum rises.

It is the condenser which is primarily responsible for the high vacuum attainable under these conditions as by means of the wedge the air is arranged in density gradations which reach a maximum at the outlet from the condensing chamber, but the disposition of the gradations at the outlet must be such that a given weight of air presents as small a surface area and as great a depth as the practical requirements of sufficiency of passage will permit of. Concurrently the air pump is enabled to maintain such an air condition within the condenser that the air density at the air outlet is minimized, the air insulation within the condenser is reduced, and the greatest amount of heat is transmitted to the condensing water.

It should again be noted that each air pump normally withdraws exactly the same quantity of air per unit of time, viz.: the quantity which enters the condenser with the exhaust steam, but in Fig. 3 a less air density is maintained at the air outlet and therefore there is less air insulation within the condenser than in Fig. 2. The relation between a condenser and an air pump may thus be seen. For example, the ability of a condenser to create a very high vacuum may always remain latent if it is worked in conjunction with an inefficient air pump. What is required is such unit efficiency that combined will enable the very highest vacuum to be maintained which the condenser is capable of producing.

The next important consideration is the proportions of

the wedges. The thin end presents no difficulty whatever. It should be so narrow that the air forms a strip or plug of such stability that eddying or disturbance is impossible. In practice the width is usually determined by the diameter of one or more tubes with the necessary allowance for the passage of condensate.

The desideratum at the top of the wedge is to stop eddying. This can best be achieved by making the wedges as for example in Fig. 4.

It will be evident that the often misunderstood problem of intermediate collection of condensate and the consequent influence on its temperature now becomes very simple. Again refer to Figs. 1, 2 and 3. In Fig. 1 no air being present there is equality in temperature throughout the condenser, and on the formation of drops of condensate they splash over tubes in their descent and are

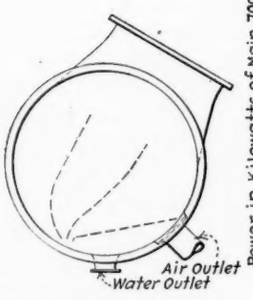


FIG. 4. CONDENSER WITH MULTIPLE WEDGE CHAMBERS

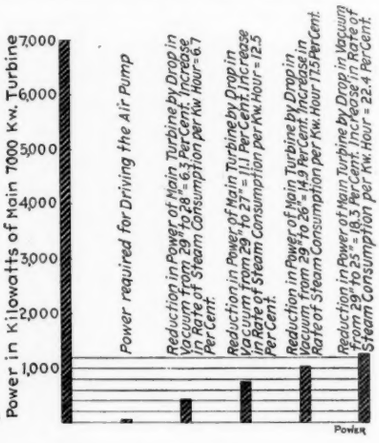

Power in Kilowatts of Main 7000 Kw. Turbine
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Power required for Driving the Air Pump
Reduction in Power of Main Turbine by Drop in Vacuum from 29" to 28" = 6.3 Per Cent. Increase in Rate of Steam Consumption per Kw. Hour = 6.7 Per Cent.
Reduction in Power of Main Turbine by Drop in Vacuum from 29" to 27" = 11.1 Per Cent. Increase in Rate of Steam Consumption per Kw. Hour = 12.5 Per Cent.
Reduction in Power of Main Turbine by Drop in Vacuum from 29" to 26" = 14.9 Per Cent. Increase in Rate of Steam Consumption per Kw. Hour 13.5 Per Cent.
Reduction in Power of Main Turbine by Drop in Vacuum from 29" to 25" = 18.5 Per Cent. Increase in Rate of Steam Consumption per Kw. Hour = 22.4 Per Cent.
POWER

FIG. 5. POWER REQUIRED BY AIR PUMP AND EFFECT OF DROP IN VACUUM

alternately cooled by the tubes and heated by the vapor until on arrival at the bottom they are approximately at the same temperature as that corresponding to the vacuum.

In Fig. 2, air being present, the temperature gradually decreases from the top to the bottom and therefore the drops of condensate when falling pass through a cold air zone with the result that the final temperature is less than that corresponding to the vacuum. The temperature of the condensate relatively to that of the vacuum therefore depends on the temperature of the air zone through which it falls, and also on the shape of the condenser.

Almost any condenser lends itself to the intermediate collection of condensate as some must fall on the sides and thus short circuit the colder air zones.

In Fig. 4 the multiple wedge chambers discharge into an air receiver which may or may not be fitted with tubes. For high vacuum tubes are very valuable as they enable the temperature of the air to be brought to within a few degrees of that of the condensing water. It will be noted that this effect is initiated in the base of the multiple wedges where many of the tubes are entirely sheltered from the streams of falling condensate and carried to its logical conclusion in the final air cooling chamber. Having obtained this high vacuum, what is its value? As will be seen by Fig. 5, in a commercial turbine plant it is represented by increased efficiency.

Dronsfield Pressure Controlling Valve

By the pressure of the air, or liquid passing through it, the action of this valve is automatically controlled. It will cut off or admit the flow at any predetermined pressure and prevent leakage of the operating ffuid which would build up a back pressure behind the valve piston.

The valve body has a horizontal projection *A* with a central piston chamber, capped at the outer end, and holding a helical spring within a piston. The piston is beveled at one end and when in its outward position, with the spring compressed, seats against a stationary seat which also acts as a stop and cuts off the flow of fluid that may travel along the exterior of the piston. Normally the spring also presses the head of the piston against a valve seat at the opposite end of the piston.

In operation the fluid passes up through the pipe *B*, but is prevented from going further by the valve piston until some predetermined pressure has been reached which overcomes the pressure of the spring against the piston, and then the piston valve is moved away from its seat, which allows the fluid to pass through the valve. When this takes place the pressure is equal on both sides

DRONSFIELD PRESSURE CONTROLLING VALVE

of the piston. As soon as the pressure decreases on the inlet side of the valve, the spring will close the piston, thus preventing any flow of fluid through the valve at any pressure less than that determined as a minimum. The fluid is always admitted to the discharge side of the valve at, or above, the pressure at which the valve is operated.

The valve is useful in any system delivering a liquid, or fluid, under pressure, as, for example, one supplying oil burners for the generation of steam wherein the fuel oil is drawn from a supply pipe, atomized and discharged into a furnace by a jet of air or steam. In such a system the valve automatically closes when the liquid in the source of supply falls below the predetermined pressure and prevents any flow from the source of supply to the discharge until the predetermined or a greater pressure is exerted against the piston. When used with an atomizer the valve is connected to it by a nipple, as at *C*.

This device is manufactured by A. J. Dronsfield, 281 Admiral St., Providence, R. I.

ELECTRICAL DEPARTMENT

The Storage Battery—II

By John A. Randolph

The storage battery, as its name implies, is essentially an agent for the accumulation of electrical energy. There are various conditions which require the use of stored energy either from an economical standpoint or from actual necessity, and it is to meet the demands of these conditions that this type of battery is used. It is employed for various purposes, but its most important application is in connection with power stations as an accumulator of reserve power and it is in this field that it is found in its largest and most complete development. As thus used, its principal functions are: to aid in carrying the peak loads, to regulate the voltage on feeders and to act as a reserve source of power which can be drawn upon when the other sources fail.

There are various methods used in the connections of a stationary battery for charging and discharging, depending upon the size of the battery, the nature of the distribution system, the load factor and the economical requirements of the station. A common method of charging the smaller sizes used for oil switch control and other auxiliary work consists in the use of a motor-generator

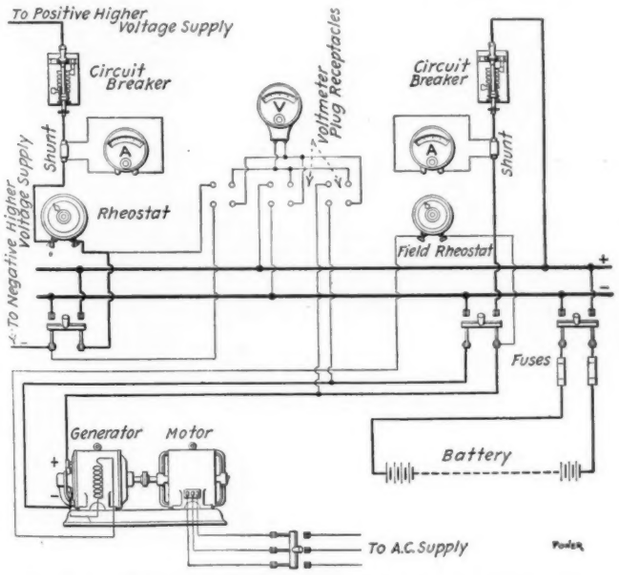


Fig. 1. Battery Arranged for Charging with either Motor-generator Set or from Station Busbars

set of small capacity, the generator being connected across the battery busbars upon charging, and disconnected when the charge is finished. In another method, the charging current is taken from a set of station busbars carrying a higher voltage than the battery busbars, the current flow due to the higher voltage being regulated by a rheostat.

Fig. 1 shows a diagram of connections for a battery that can be charged by either of these two methods. The motor-generator set is driven by a motor whose current is furnished from the auxiliary supply mains of the station. In substations, an induction motor is generally used in order to have the charging set available at times when the direct-current station busbars are dead. The generator is connected through a switch and circuit breaker to the battery busbars. The supply leads from the station busbars are likewise connected to the battery

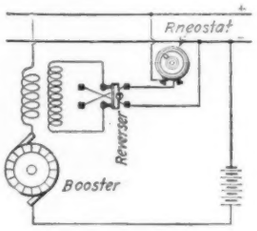


Fig. 2. Booster Connection on Two-wire System

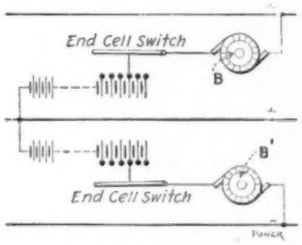


Fig. 3. Booster Connection on Three-wire System

busbars and a rheostat is connected in series with the positive side. By means of a voltmeter and plug receptacles connected as shown, the voltage of either charging source and of the battery can be ascertained at any time. The ammeters show the charging current of the respective sources and the flow is regulated by means of the rheostats. When a charge is completed, the circuit-breaker and main switch on the source used is disconnected, and the battery, which remains connected to its busbars, begins to discharge simultaneously. By this arrangement the continuity of service to the circuits fed from the battery busbars is not interrupted, the current being supplied during charge by the replenishing source.

With large batteries employed on the outside service of the station a different procedure is followed. These are generally used in conjunction with boosters upon both charging and discharging. The latter are low-voltage direct-current generators so connected that their pressure is added to that of the station busbars upon charging, and to the battery voltage during discharge. Were it not for the assistance of the booster, it would be impossible to send a charging current through the battery from the station busbars, after its voltage had been brought up to that of the latter. Moreover, it would be impossible to discharge the battery below this point.

Fig. 2 shows a fundamental diagram of one of the many methods used in connecting a battery and booster to a two-wire system. The booster is compound wound, the shunt field being capable of reversal through a pole-changing switch. By means of the latter, the booster voltage is added to that of the main busbars upon charge and is therefore opposed to the battery pressure, the result being that a current is caused to flow through the battery in the required direction, which is opposite to that of discharge. In discharging, the booster shunt field is

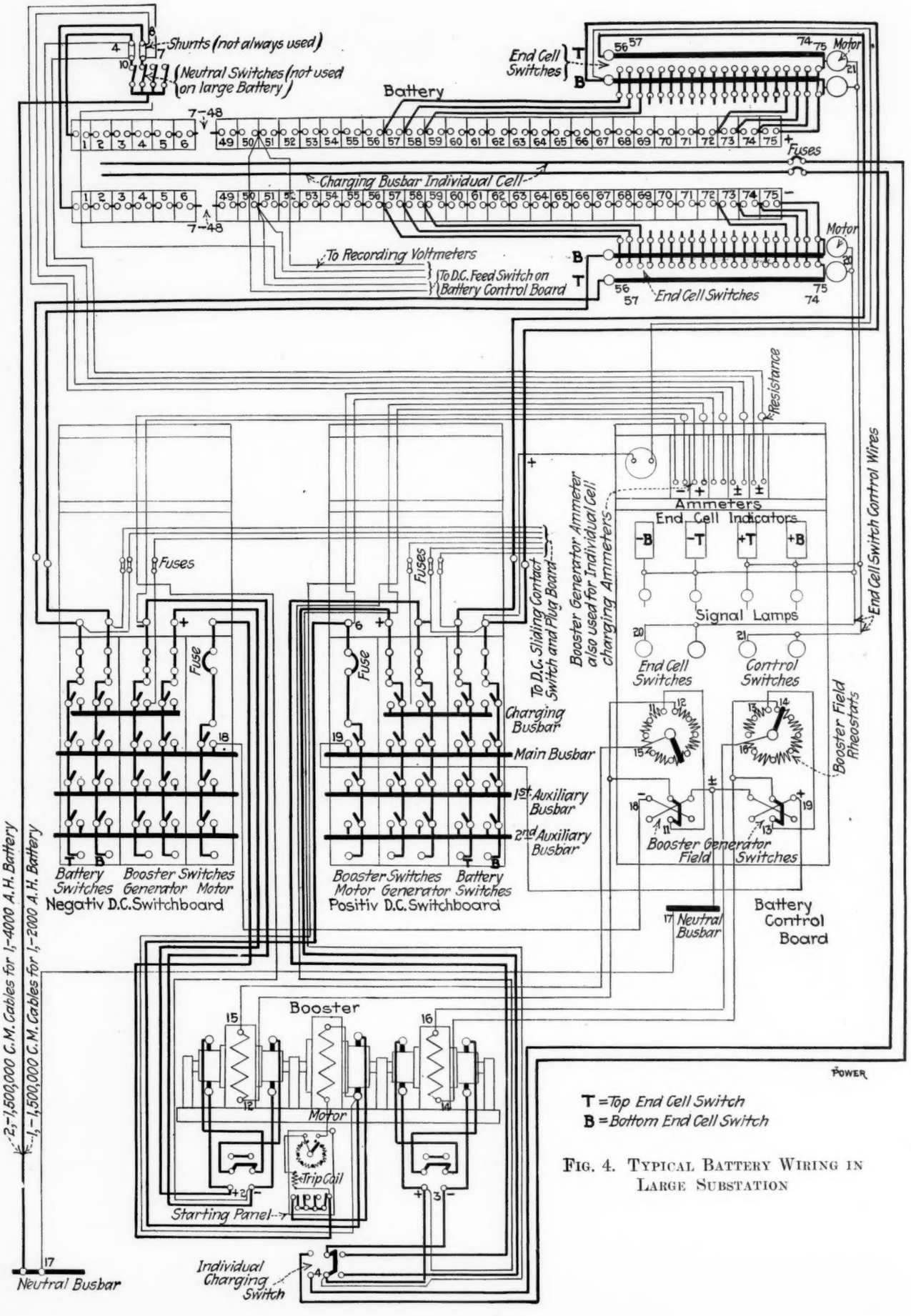


FIG. 4. TYPICAL BATTERY WIRING IN LARGE SUBSTATION

reversed and the voltage of the machine assists the battery in overcoming the opposing pressure of the main busbars sufficiently to deliver its current.

In Fig. 3 is shown a method of connection commonly used on substation batteries employed on a three-wire lighting system. The two booster generators are respectively connected in series with corresponding halves of the battery, the busbar connections for each half being made with an outside leg and the neutral. A detailed wiring diagram for this method is shown in Fig. 4.

The polarity of the booster is established, as required, by the field reversing switches shown on the battery control board. In addition to the booster, another means is provided for regulating the battery voltage. This consists of a number of units known as end cells, which are so arranged that they can be connected in series with the main battery circuit or disconnected therefrom without interrupting the continuity of service. This is done by means of sliding contact switches moved by threaded shafts driven by motors controlled from the battery control board. The arrangement of the end-cell switch connections, contacts, sliders and motors is shown in the diagram (Fig. 4).

It will be observed that the end-cell switches are provided with two sliders, a double set of contacts, and two main leads. There are several reasons for this: one is, to insure continuity of service by not making the latter wholly dependent upon one outfit. If only a single equipment were used and a vital part became out of order, the battery would be thrown out of service, whereas with a double equipment, if one line should be out of order the other could be used. Another reason is that a cross-section of copper is thereby provided, sufficient to meet the demands of the heavy currents involved, without incurring the inconvenience and extra labor necessary to incorporate this sectional area in a single line and one set of contacts.

Two small individual-cell charging busbars are shown extending through the battery room. These are so located that temporary connections can be made thereto from any cell in the room. They are for the purpose of charging independently of the main battery any cell which may have been found defective.

Care and Management

In the economical management of a storage battery, careful and systematic attention must be exercised in charging and discharging, replenishment of the electrolyte and cleaning and repairing in order to preserve the life and efficiency. The charge may be begun at about double the normal discharge rate for the first hour and gradually reduced to a low rate (say one-fifth normal) near the end. The current should be discontinued as soon as the charge is complete, which latter varies with the different types and depends upon the size and number of plates. Although a charge should be continued until both plates gas freely, if the charge is maintained too long, the gassing will cause the active material to be gradually loosened from the grids, breaking off and dropping to the bottom of the cell where it accumulates. If not removed, it will in time increase in depth until it comes into contact with the plates, thus causing an internal short-circuit. Moreover, excessive gassing causes the electrolyte to evaporate, rendering replenishment necessary more often than under normal conditions.

There are two methods commonly used in determining the proper duration of charge and discharge, namely, taking voltage readings and noting the specific gravity. When used in conjunction, they form a fairly accurate means of determining the time when the current should be discontinued. Upon charging, the voltage gradually rises. When it reaches a value of about 2.45 per cell, the battery can be said to be charged, providing a test of the electrolyte shows a specific gravity of 1.204. However, while the battery, as a whole, may show these average voltage and gravity values, the readings, when taken on the individual cells, may vary slightly, but will not be far from the average, providing the cells are in good condition. On the other hand, if any of the cells are sluggish, a pronounced difference will be noticed due to the incomplete reduction of the sulphate on the previous charges. These cells will require a longer charge than the others, but this is not necessary at every charging period.

An overcharge of the entire battery once every week or two, depending upon the frequency of the regular charging periods will generally be sufficient to reduce the sulphate remaining after normal charge and to thus even up the voltage and gravity of the individual cells. The duration of the overcharge is determined by voltage and gravity readings as in the case of normal charging. When these values reach a maximum and show no further rise in observations taken at short intervals over a period of an hour and a quarter, the overcharge should be stopped providing the battery is gassing freely. The maximum voltage attained upon overcharge will vary from 2.4 to 2.65 per cell, depending upon the age and conditions of the battery.

The same methods are used in the determination of the length of discharge as are used in the charge. The voltage, upon normal discharge, falls gradually, its drop being more rapid near the end. In general, the limit of discharge can be said to be about 1.75 volts per cell with current flowing at the normal rate. Moreover, the specific gravity of the electrolyte falls in proportion to ampere-hours discharged. The fall in specific gravity is dependent upon the quantity of solution as compared with the bulk of the plates. Ordinarily, if the specific gravity upon overcharge is 1.209, the limit governing the discharge should be about 1.174.

The battery should be regularly inspected to ascertain the condition of the cells. If any are found that compare unfavorably with the others in regard to voltage, color of plates or condition of the electrolyte, they should be given careful attention at once and watched closely until they return to their normal condition. A defective cell will not gas as actively as the others and its plates are usually lighter or darker in color than those of the other cells.

Careful use, an occasional cleaning and an early detection and removal of the causes of any abnormal conditions which may develop, will indefinitely prolong the life of the battery.

Locking Device for Disconnecting Switch

The illustration shows a locking device that effectively prevents the blade of a disconnecting switch from opening except under the direction of the operator. Instances are on record where the blade of a disconnecting switch

not protected by this device has been thrown open or partly open by magnetic repulsion and destroyed when a short-circuit has occurred on the line, not only resulting in the loss of the switch but also putting the circuit on which the switch was installed out of commission until a new switch could be installed, unless there were duplicate circuits.

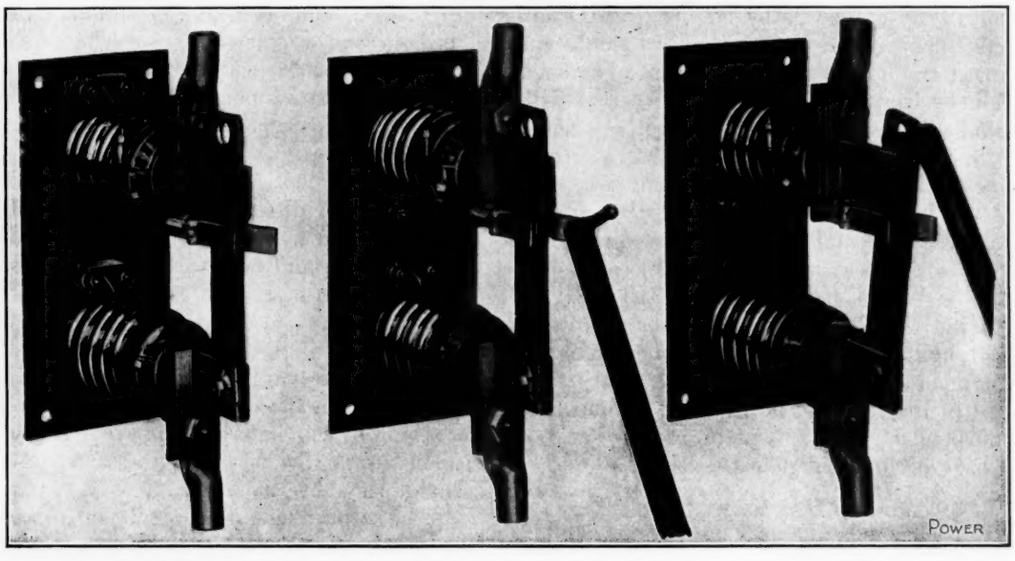
This locking device consists essentially of two brass bell cranks hinged together at the ends of the two shorter arms and held closed by compression springs. The projections or jaws in the outer ends of the two longer arms close in front of the blade, thus preventing the latter from coming out of the clips. Each bell crank is provided with a dog which moves in a slot in the bell crank's elbow, the dog being hinged at this point. Two compression springs, one pressing outward from the switch base against the elbow of each crank and also against the dog, keep the bell cranks closed and the dogs pressed against the back of the switch blade.

To open the switch, the outer ends of the bell cranks are pressed back away from the blade, allowing the dogs to come forward so as to rest upon the sides of the blade, in which position they hold the jaws in front of the blade apart, allowing the switch to be opened. Withdrawing the blade of the switch from between the dogs causes the jaws to automatically close against the sides of the blade and to snap shut as soon as the blade is completely withdrawn. These operations are shown in the illustrations.

As the outer edges of the jaws are beveled the switch blade can be readily pressed back in the clips into the closed position, when the jaws close automatically in front of the blade locking the latter in the closed position.

The operator does not have to remember to lock the switch closed, as it automatically locks itself, and thus guards against damage.

The device is made by the General Electric Co. in sizes to fit 300-, 600-, 800- and 1200-amp. switches. Since the safety catch is a unit in itself it can be applied to any G. E. type L-switch merely by clamping it to a support between the clip block and the insulator cap.

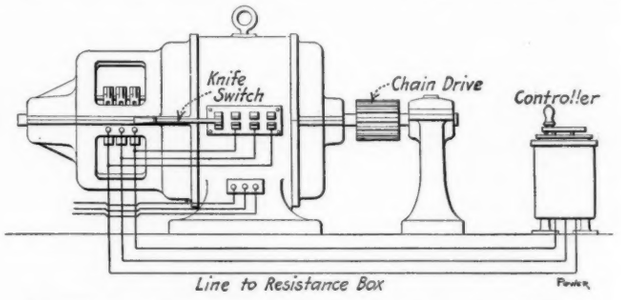


SWITCH IN CLOSED POSITION AND IN ACT OF BEING OPENED

CORRESPONDENCE

Short Circuiting Lines to Controller

We were bothered with the resistance becoming overheated in the controller of a 200-hp. induction motor driven from a 550-volt line. The heating was caused by bad contacts, which appeared to be in fair condition. To remedy this, wires were spliced onto the resistance wires and led to contacts on a board screwed onto the motor frame. On this board was mounted a knife switch. When starting the motor this switch is open, but when the motor is up to speed, and all the resistance is cut out, the knife switch is closed and short-circuits the line to the controller. The arrangement is shown in the sketch.



METHOD OF SHORT-CIRCUITING CONTROLLER WIRES

JAMES A. CAMPBELL.

Providence, R. I.

In a lecture before the International Congress of Applied Chemistry, New York, Sept. 11, 1912, Giacomo Cimician, of Bologna, Italy, stated that a square yard of the earth's surface receives each day (tropical day of six hours) an amount of heat equivalent to that in about 1.8 lb. of coal. A square mile would therefore receive each day heat equivalent to the combustion of over 2600 tons of coal. The quantity of coal and lignite mined annually in Europe and America is about 1,100,000,000 tons, and an area of about 1200 square miles—that of a fair-sized American county—receives during the year from the sun an amount of energy equivalent to that obtainable from this coal output.

GAS POWER DEPARTMENT

Diesel Engine Driving Rolling Mill

By Dr. Alfred Gradenwitz

The 450-hp. Diesel engine plant of the Achenrain Brass Works, at Kramsach-Achenrain, Northern Tyrol, is of special interest on account of the particularly unfavorable working conditions to which the Diesel engine has in this case been adapted. This firm in 1909 installed a 700-hp. water turbine of the Francis type, utilizing the water power of the Brandenberger Ache. The energy was conveyed by a high-tension transmission line to the rolling mill situated about one mile distant. The variations in the amount of available water, however, induced the managers to install a Diesel engine as a standby.

Fig. 2 represents the load in rolling and pressing during two consecutive pressing processes and simultaneous rolling on five frames. The fluctuations attending this rolling and pressing process are seen at a glance; those corresponding to the switching in of the huge hydraulic press, where rods are pressed hot out of the ingot, are as high as 300 per cent., being close to 400 hp. The maximum loads as well as their duration are variable, depending on the resistances met with in the press and on the temperature of the ingot. In designing the engine the fact that the speed does not decrease during the maximum performance had to be taken into account. Also, an ample overload capacity of the motor had to be provided.

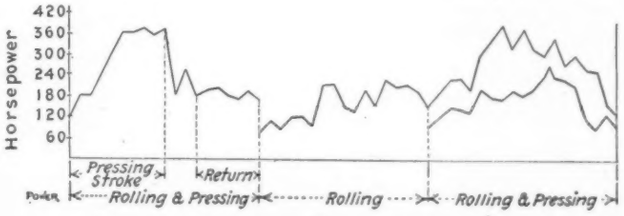


Fig. 2. Showing Variation of Load

To provide for sudden variations in load, an exceptionally heavy flywheel had to be included. This is of cast steel, 16 ft. in diameter. Its rim weighs approximately 11 tons and the total weight of the flywheel is 90 lb. per engine horsepower.

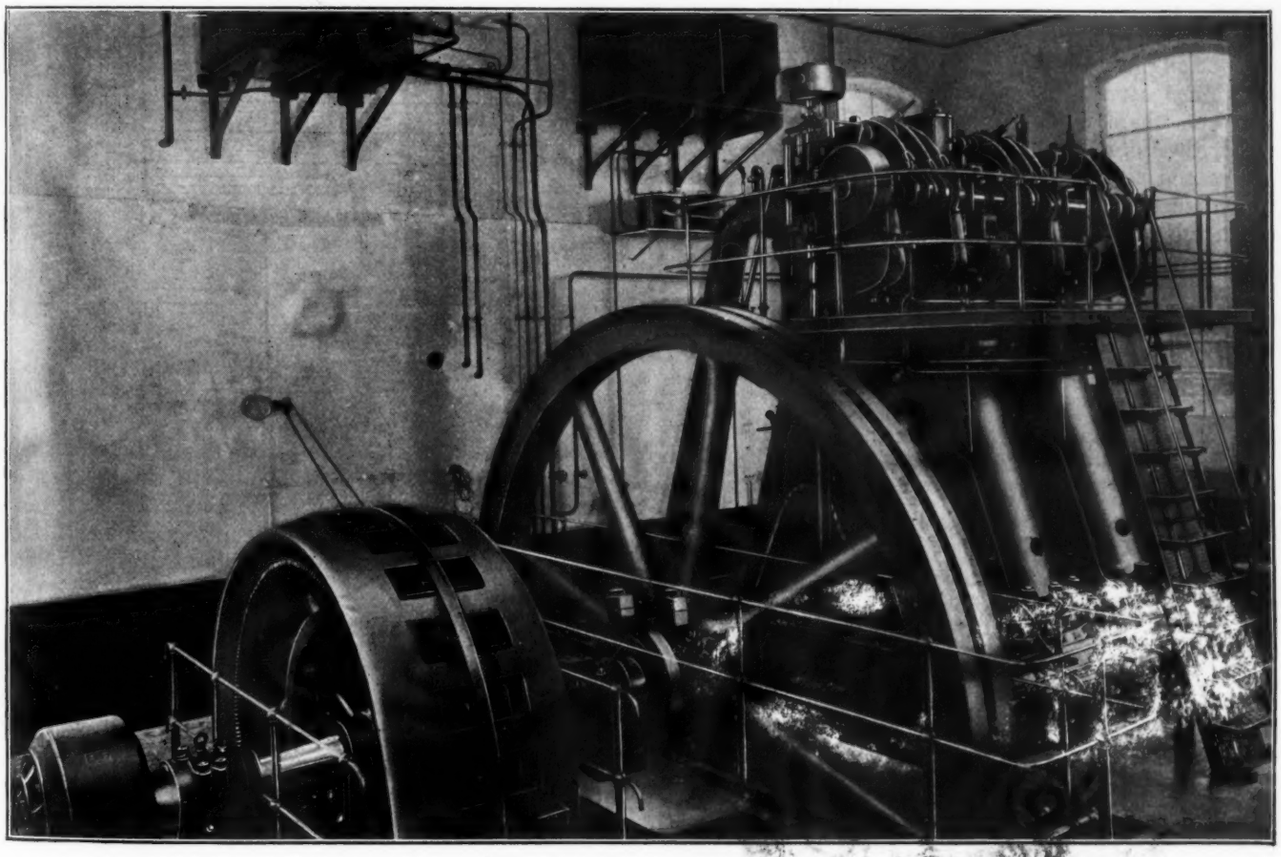


Fig. 1. Diesel Engine and Generator

The Diesel engine is a three-cylinder four-stroke-cycle machine the cylinders being 20 in. in diameter and 30-in. stroke and the normal speed 168 r.p.m. It is coupled direct to a three-phase generator supplying the motors which drive the rolling mill. The engine is of normal design, but in view of its special purpose and its overload

capacity it is built particularly heavy. The compressor is mounted on the shaft of the generator.

In connection with tests made on delivery, the crude-oil consumption of the Diesel engine at full load was found to be 0.432 lb. per hp.-hr. This rather high figure was due mainly to the fluctuations in load, which occurred during the test. The slowing-down time of the engine was found to be 4 min., 50 sec., and with the suction valves lifted, 8 min., 52 sec., which shows small friction. Its mechanical efficiency, inclusive of the compressor, was 75 to 79 per cent. The thermal efficiency

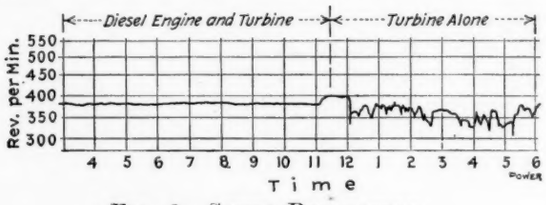


FIG. 3. SPEED REGULATION

was found to be 32.2 per cent. at full load, and 28.1 per cent. at half load.

Fig. 3 shows a tachometer record at the power station during a typical night load. Until 11 o'clock the Diesel engine ran in parallel with the water turbine, but after this time only the turbine was kept in service. Although the working process at the rolling mill was quite identical before and after 11 o'clock, the record shows that before this time there were no appreciable fluctuations in the speed, the Diesel engine effecting perfect compensation. The second part of the diagram, which corresponds to exclusive turbine operation, shows the speed variations to which the turbine was subjected.

Last summer this installation was put to a decisive test, the turbine generator windings being burnt out by lightning, so that the Diesel engine during ten weeks had to supply continuously all the power to the works.

❖

The Low Coal Engine

The direct utilization of coal in a gas engine forms the basis of an invention by Dr. A. M. Low, which is attracting considerable attention in England. Speaking generally, Dr. Low's engine occupies a position in the

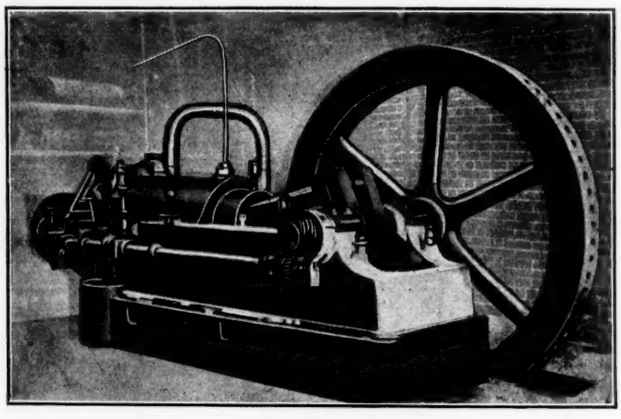


FIG. 1. THE LOW COAL ENGINE

gas-power field very similar to that of the locomobile in steam-engine practice; that is, it is a self-contained unit for converting the heat in the coal into mechanical energy at the engine shaft. Of course, it has not yet attained the refinements of the locomobile and is still in a more or less experimental stage. The important fact is that it runs successfully and is claimed to have produced a brake horsepower-hour on about ½ lb. of coal—a remarkable performance, if true.

The present engine, which is rated at 100 hp., is shown in Fig. 1, and Fig. 2 represents a section through the coal-feeding device at the head end.

Referring to Fig. 2, coal is fed into the hopper *A* from which it is conveyed by four worms through the heater tubes *T*. These tubes pass through the gas chamber *G*, connected with the inlet valve, the exhaust heated chamber *E*, the combustion chamber *C* and open into the ash and soot chamber *S*. The latter is fitted with a nonreturn valve which admits air or a mixture of steam and air to the tubes. This air is drawn by the suction of the engine over the incandescent coal, maintained in this state by the heat of chambers *C* and *E*, and passes through holes in the tubes *T* into chamber *G*. It is by this time

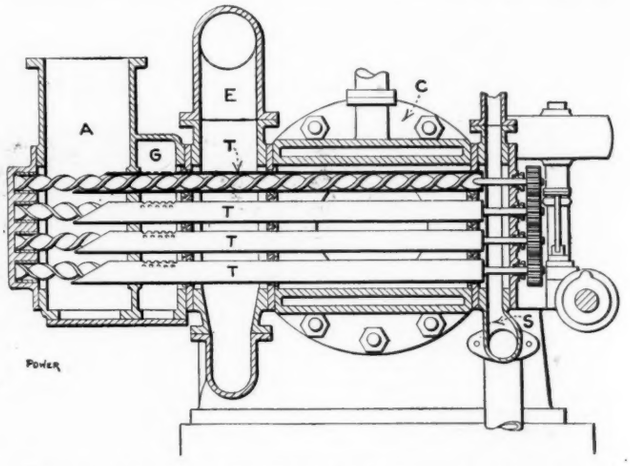


FIG. 2. SECTION THROUGH COAL-FEEDING AND GAS-FORMING DEVICE

mixed with the gases given off from the incandescent coal and the mixture passes from chamber *G* through the inlet valve into the cylinder of the engine.

In starting, the coal is brought up to incandescence by running for a few minutes on illuminating or other available gas.

The feed of the worms, which are driven through gearing at the right, may be adjusted to suit the load, and the coal after it has given off all its gas is discharged as ash into the bottom of the ash shoot *S*.

With no gas-cleaning apparatus one would expect to encounter trouble from the tar. No such trouble has been experienced, however. This, Dr. Low ascribes to the fact that the coal is heated rapidly and in small quantities; hence the tar is not gasified but passes off in the form of fine yellow dust. The high temperatures and relatively low compression, about 90 lb., prevent these fine particles of tar from being condensed and precipitated in the engine passages; hence they pass off as yellow smoke in the exhaust.

❖

R. F. Halliwell, in a paper upon "Recent Developments in Curtis Steam Turbines," read before the Manchester Association of Engineers, says that in the Curtis turbine as built by the British Thomson-Houston Co., at Rugby, England, it is usual to provide about ⅛-in. axial and $\frac{3}{16}$-in. radial clearance.

Vaporizers for Producers Using Wood Fuel

A claim is made by builders of certain suction-gas generators using wood for fuel that, on account of the moisture in this class of fuel, it is unnecessary to incorporate a vaporizer for enriching the gases.

In these generators the air is drawn in beneath the fuel column, and the fuel is fed from above, as a consequence of which the temperature varies from that of the highly incandescent fuel at the bottom to that of the comparatively cold fuel near the hopper. The temperature at which the gases pass the last fed fuel will be insufficient to more than vaporize the moisture in this fuel, which will pass off as steam along with the gases. Even were the vapor decomposed, the oxygen, meeting no carbon at this point, would pass away in a free state.

To the writer, it would appear then that the claims made have no support in fact. In the first water-gas plant erected in England, a similar argument was advanced as the forerunner of a distinct improvement. In this producer the steam was first admitted above the fuel, and as a consequence the latter became so impregnated with moisture that it was difficult to drive off the moisture during the next blow. Hence it was found unprofitable to use the gas for furnace work, and it was allowed to blow into the atmosphere—a dead loss of millions of cubic feet, besides being the source of much complaint from the people of the surrounding district.

With a view to rendering possible the utilization of the producer gas, the steam arrangement was modified to permit the steam being admitted below the fuel column. This proved successful.

The moisture in the fuel of a suction plant would have a similar influence in weakening the gases as had the saturated fuel in this water-gas plant. With much moisture and consequent extreme vapor production, the gas production would be considerably lessened, the suction from the engine being not much more than sufficient to draw off the vapor, which, of course, would be condensed in the scrubber.

It is probable that a damp coal is responsible for the difficulties occurring at times in suction plants, particularly at the commencement of a run.

Manchester, Eng. FRANCIS W. SHAW.

Consuming Gas Engine Smoke

Gas engines are often fitted with crank-case relief valves which sometimes allow considerable smoke to escape. The three engines of which I have charge made the air blue until we put in 1½-in. pipe from the relief valve of each engine to the 4-in. intake pipe. At the lowest point in the 1½-in. line we arranged a ¼-in. line to drain off the small quantity of oil which is apt to get past the relief valve. This arrangement allows the smoke to be consumed in the cylinders, keeps the engine-room air fit to breathe and the mixing valves do not need any more cleaning than before.

Kane, Penn. FLOYD L. FRAZINE.

Gas Engine Troubles

BY H. LOCKE

Difficult starting	Incorrect mixture	Mixture too weak owing to insufficient gas	(1)
		Mixture too rich owing to insufficient air	(2)
	Defective ignition or failure to ignite	Tube not properly heated	(3)
		Timing valve incorrectly adjusted	(4)
		Vibrator out of adjustment	(5)
		Sparking plugs too far apart or dirty	(6)
		Wire disconnected or short circuit	(7)
		Batteries weak or coil defective	(8)
	Engine too cold; see lines (9) and (10).		
	Incorrect mixture; see lines (1) and (2).		
	Defective ignition; see lines (3) and (8).		
Lack of power	Engine too cold	Jacket water turned on too freely or too soon	(9)
		Water lodging in cylinder, leaky jacket joint	(10)
	Engine too hot	Defective circulation of cooling water or insufficient supply	(11)
		Faulty lubrication	(12)
		Exhaust cam worn, causing insufficient opening of exhaust	(13)
		Mixture too rich	(14)
		Too high compression owing to carbon deposit	(15)
	Leakage during compression	Piston rings worn or sticking in grooves	(16)
		Liner worn or grooved	(17)
		Leaky valves	(18)
	Ignition too late.		
Pounding and knocking	Parts of engine loose or worn	Connecting rod or main brasses slack	(19)
		Flywheel loose	(20)
	Moving parts striking an obstruction.		
	Broken piston ring.		
	Spark advanced too far.		
	Spark too early.		
	Cylinder and piston overheated; see lines (11) and (15).		
Preignition	Too high compression.		
	Glowing carbon or metal points in the cylinder and burning gas	Pockets for gas to accumulate	(21)
	Ignition uncertain.		
Backfiring	Delayed burning of previous charge	Pockets for gas to accumulate	(21)
	Incorrect mixture	Too much air	(22)
	Valve timing wrong, inlet late in closing.		
	Leaky inlet valves.		
Explosion in exhaust pipe	Accumulation of unburnt gases	Previous charge too rich	(23)
		Ignition uncertain	(24)
	Exhaust valve leaky	Valve or seat bad	(25)
		Dirt under valve face	(26)
		Weak spring	(27)
	Exhaust opens early	Incorrect timing	(28)
Poor speed regulation	Variation of gas pressure	Gasometer body balanced or rusted in guides	(29)
		Irregular working of plant	(30)
		Leakage of air in producer	(31)
	Pallets on striker worn.		
	Governor stiff or worn	Want of lubrication	(32)
		Poor adjustment	(33)
Excessive fuel consumption	Incorrect mixture.		
	Engine too cold; see lines (9) and (10).		
	Leakage; see lines (16–18), and (25–27).		
Smoke	At end of exhaust pipe	Mixture too rich—smoke black	(34)
		Excessive cylinder lubrication—blue smoke	(35)
	Past piston.		

HEATING AND VENTILATION

Condensing Plants for Large Commercial Buildings

By Ira N. Evans

It is remarkable that in recent years little or no change has occurred in methods of heating large commercial and office buildings. Many new appliances in the form of thermostatic and float traps for use on the individual radiators of vacuum systems have appeared, which have merit and are designed to prevent the vacuum from communicating with the heating system proper. Little or no progress, however, has been made in utilizing the condensing capacity of a heating system to reduce the steam consumption on the engines by operating on pressures below atmosphere at the exhaust outlet of the machine.

It is almost impossible to make a large steam-heating system air-tight on pressures below 10 in. of vacuum. Yet there are numbers of large heating systems that require 300, 400 and even 1000 hp. and have a cooling or condensing effect to that extent.

In manufacturing plants where water is scarce, cooling towers are used extensively and with success. The cooling tower is a device for mechanically evaporating a portion of the injection water and thereby lowering its temperature so that it can be utilized over and over in a surface condenser.

The tower may be placed on the roof or in the basement and the water circulated between the tower and condenser by a pump, the head on the pump being that due to the friction of the piping and the height of the tower. There are several forms of cooling tower embodying the principle of bringing air in contact with a film of water in order to assist the evaporation. The quantity of air required depends on the area of water surface presented, and the hotter the air and the lower its humidity, the better its absorbing power. Convenient sources of hot air are the engine and boiler rooms. Ventilation of these rooms might be readily effected by drawing the hot air to the tower, and thus combining two operations in one. Where the building is high, a good flue will furnish natural draft at slight expense.

There are few office buildings that do not have a peak lighting load 100 per cent. greater than the average power load, and many buildings have 100,000 sq.ft. of radiation which would have a condensing capacity averaging 20,000 lb. of steam per hr. This surface is designed to operate at or near 212 deg. in zero weather on account of possible back-pressure and could be operated at 150 or 160 deg. and 20 in. of vacuum 75 per cent. of the heating season if it were possible to make the steam system air-tight. It is readily seen that an engine operating against 20 in. of vacuum is far more economical than when operating against 3 lb. back pressure or perhaps atmospheric pressure.

When hot water under forced circulation is used for heating, the necessity of making the system air-tight disappears, except in the short steam line to the exhaust heater and the steam chamber of the heater. The hot-water system then becomes an adjunct of the condenser to produce vacuum on the engine, if not allowed to become overheated, and thereby reduces the capacity in condensers which would ordinarily be required.

When a condensing plant is proposed for an office building, it is at once asked where the water is coming from and what it will cost. An accompanying remark is that steam is required for heating seven months and the saving by operating condensing the other five months would not pay the interest on the investment for condensing equipment. With a steam system this may be true and yet many cases occur when 1000 hp. in exhaust is thrown away when the maximum that could be used on the heating is 500 hp. This calls for a total installation of 1500 hp., which condensers would reduce considerably.

If it will pay to operate 1000 hp. condensing with a cooling tower in Oshkosh, there is no reason why it will not pay in New York, especially when it can be combined with heating, ventilation and other necessary operations.

When the condensing equipment can be considered, the turbine occupying one-half to one-quarter the floor space required by a reciprocating engine becomes an object of interest. In connection with hot-water heating it can be operated at high economy, but with a vacuum steam system its steam consumption would be prohibitive. The average daily power load nearly balances the heating in buildings of this character in zero weather and can be made to balance it at all outside temperatures with hot water by varying the vacuum. The peak lighting load, during which the excess exhaust steam is generally thrown away, can be operated under full vacuum. The condensing capacity required for the peak lighting load in winter will about take care of the summer load where no heating is operative. In a 1500-kw. plant only 1000 kw. in condensing capacity will be required to carry vacuum at all times if there are 100,000 sq.ft. of hot-water radiation to take care of the extra 500-kw. load in winter. The radiating surface required need be no greater for the hot-water system as the surface in both systems for zero weather may be based on a temperature of 212 deg. in the radiators.

There should be no insurmountable difficulty in finding space for the cooling tower, as all large buildings have more or less undesirable space either in the basement or on the roof that can be used. In the basement the space saved by the installation of turbines would go a long way in making room for the tower.

As to the amount of water used in the plant there will be a saving by the installation of a condenser and cooling tower. An average water rate at the switchboard would be for noncondensing conditions 32 lb. per kw.-hr. This amount for the load not required for heating is usually wasted to the atmosphere. A cooling tower requires about 1 lb. of water per pound of steam condensed.

If the water rate for full vacuum is 21 lb. per kw.-hr. at the switchboard then 21 lb. of water will be evaporated to the atmosphere from the tower, while the 21 lb. of condensation will be returned for boiler purposes. This makes a net charge of 21 lb. per kw.-hr. instead of 32 lb. for that part of the load in excess of the heating load. Where the peak or excess power load over that required for heating is 500 kw. or more, the saving in water would be a considerable item.

Where the hot-water heating system is combined with the cooling tower there will be only a few hours in the year when some vacuum cannot be carried on the heating load, and full vacuum can be carried summer and winter on all power except that required for the heating system.

If a driven well is available, although the water may be unfit for boilers, it would be all right for make-up water for the cooling tower, and a limited flow would be sufficient. Only a small percentage of city water would be required as the condensation in the condenser would be saved.

If some of the real-estate operators could see this it would make some building operations pay where there would be a deficit under the present arrangement. It is a well established fact that a condensing plant is 25 per cent. more efficient than a noncondensing plant, and that hot-water heating with a variable temperature is 25 per cent. more economical than a steam system operating at a constant temperature without heat control. If a building used $20,000 worth of fuel per year under the exhaust-steam heating method, the saving by forced hot water with condensing equipment would be $5000, which would be sufficient to pay the interest on a $100,000 mortgage at 5 per cent. At the same time 25 per cent. of the boiler capacity could be omitted with the attendant saving.

When automatic heat control is applied to a steam system there would be no saving during periods of surplus power load, as the same amount of steam would be generated whether utilized or not and more would be thrown to the atmosphere than if heat control were not applied. The same is true of a hot-water system if the condensing feature is not installed. Heat control on steam and forced hot water will, however, enable a saving to be made at night and periods when the steam for heating is in excess of that furnished by the power.

With a turbine unit on hot-water heating the same load within 10 per cent. can be carried from September to May and just enough steam furnished to provide for all outside weather changes from 0 to 70 deg. by simply varying the vacuum. This has been demonstrated in actual practice. Overheating of the rooms will be eliminated and there need be no occasion for opening windows and wasting heat to the atmosphere.

There is no limit to the height of a building to which this system may be applied as the system could be divided into independent units at varying levels in order to limit the static head to the commercial working pressures of the apparatus. It is impossible to obtain the maximum power economy with a hot-water system operated in this manner, when the power load furnishes an excess of exhaust steam, without the cooling tower, even when it has little or no work to do. Where the heating requirements are in excess of the power load it is of slight importance what may be the water rate per kilowatt-hour, so long as the heating system utilizes the steam exhausted.

Hot water has been used in many places where long distances were the deciding factor over low-pressure steam. If it is feasible when the system is spread over a large area, why not when extended into the air, dividing the system into units at varying levels?

If cooling towers and condensing equipment will pay without any heating system with cheap coal and a spur track into the plant, why will it not pay in an office building with expensive coal, a heating system to take part of the duty and a ventilating chimney high enough to provide natural draft for the cooling tower. In many cases a fresh air supply for ventilation in connection with a hot-water system will reduce the size of the cooling tower still further.

When a portion of the equipment is operated condensing with a cooling tower, the logical heating system will be hot water, and by means of it the remainder of the power equipment may be operated under partial vacuum, so that condensing conditions may be maintained at all seasons.

All of the operations mentioned previously are individually common practice and standard machinery is available. It seems a logical conclusion that if they will pay separately they should give better results when combined in one installation. The same limit governs the condensing engine here as elsewhere; that is, a size that will give sufficient return to pay interest and depreciation on the extra equipment. The minimum load would be about 200 hp. for a fair percentage of the year. It seems inconsistent for engineers to recommend cooling towers and condensing equipments for plants in one locality and yet waste steam at a higher rate in plants of equal or greater capacity where the conditions for condensing are more favorable.

CORRESPONDENCE

Water Leaves Boiler

The heating system in the school in which I am employed is supplied with steam by three sectional cast-iron boilers set to blow off at 15-lb. pressure. It takes too long to get up heat as I cannot let the fires go full draft over 20 or 30 min., before the return pipes will start kicking. Then the water begins to leave the boilers, requiring closing of the drafts for a short time to allow the water to return. Then the drafts are turned on again and the same operation repeated all day. When the drafts are closed there is about ½-lb. pressure and quite often the radiators in the wing of the building are cold. The building, which is three stories high, is 200 ft. long and 65 ft. wide for 110 ft., the other 90 ft. being 50 ft. wide.

The boilers are at the middle front with a 3½-in. supply pipe running each way and also a 3-in. pipe running over the boilers to the wing at the back. It is a one-pipe system with return pipes ¾, 1 and 1¼ in. near the boilers, except for the back wing which has a 1¼-in. return all the way. I would like to know the cause of the trouble and hope POWER readers can help me out.

LUTHER WALLING.

Brantford, Ont., Canada.

Heating a School

In an article in POWER of Dec. 10, by Fred L. Wagner, there are several calculations with which I do not quite agree; at least, I think there may be a better way used to arrive at the desired results.

As 56,000 cu.ft. of air per min. are to be used for ventilating purposes, this air must be raised from outdoor temperature to 70 deg. as given, but this air will have to be raised to a still higher temperature in order to take care of the 1,122,100 B.t.u. per hour loss from the walls, etc. Letting T be the final temperature required and 70 deg. the temperature of the room, gives

$$T = \frac{55 \times 1{,}122{,}100}{56{,}000 \times 60} + 70 = 88.5 \text{ deg.}$$

Allowing 6.5 deg. drop due to radiation losses from the piping between the heater and rooms, a final temperature of 95 deg. leaving the heater will be required instead of 120 deg. as suggested by Mr. Wagner.

From tables furnished by the Buffalo Forge Co., I find that their heater 20 rows deep with a velocity of 1200 ft. per min. through the heater will raise the temperature of the air from 0 to 97 deg.

Allowing a velocity of 1200 ft. per min. through the heater, a clear area of

$$56{,}000 \div 1200 = 46.6 \text{ sq.ft.}$$

will be required, and using two sections back to back the clear area of each will be 23.3 sq.ft., that is, the heater will be 20 rows deep with a total clear area of 46.6 sq.ft. Referring again to the tables, the square feet of surface in the ten four-row sections will be 2900 sq.ft. instead of the 5400 sq.ft. allowed by Mr. Wagner. While extra surface is often added to the heater to allow for rapid heating, in school work it is much better practice to so arrange the system that the air may be recirculated when warming up in the morning.

Using 2 lb. of steam condensed per square foot of heating surface gives

$$\frac{2900 \times 2}{34.5} = 168 \text{ boiler hp.}$$

The ten four-row sections of the 7x7-ft. 4-in. heater will contain 8450 lin.ft. of 1-in. pipe and under the conditions assumed will deliver 706 B.t.u. per lin.ft. per hr.

$$\frac{8450 \times 706}{960 \times 34.5} = 180 \text{ boiler hp.}$$

This practically agrees with the editor's note in connection with the above article, and the editor's method is really the correct way to determine the boiler horsepower.

The sizes of fans and engines given by Mr. Wagner are correct for the conditions he has assumed. The velocity through the heater, 1200 ft. per min., is too high for school work, as is also the resistance of ¾ oz. assumed for the fan. By lowering the velocity through the heater to 1000 ft. per min. the resistance will be only 69 per cent. of that at 1200 ft., thus reducing the pressure at the fan. The conditions assumed would be all right for a shop but would in all probability prove too noisy for a school. By using a size larger fan at ½-oz. pressure both the speed and horsepower will be greatly reduced. Using two blowers, each with a 90-in. wheel at 170 r.p.m. will require only 8 hp.

FRANK L. BUSEY.

Buffalo, N. Y.

Rearranging Heating Coils

In the issue of June 11, page 842, I showed a sketch, Fig. 1, of a coil used for heating one part of our factory and with which we had trouble last winter. I also asked the readers for an improvement over the method shown in Fig. 2. The 200 ft. of pipes were cut into three sections. In Fig. 3, two of the three sections are shown. The supply pipe was run to the last section, with a valve near each section. To allow for expansion and contraction the branch tees are connected to the coils, as shown at *A* in Fig. 3.

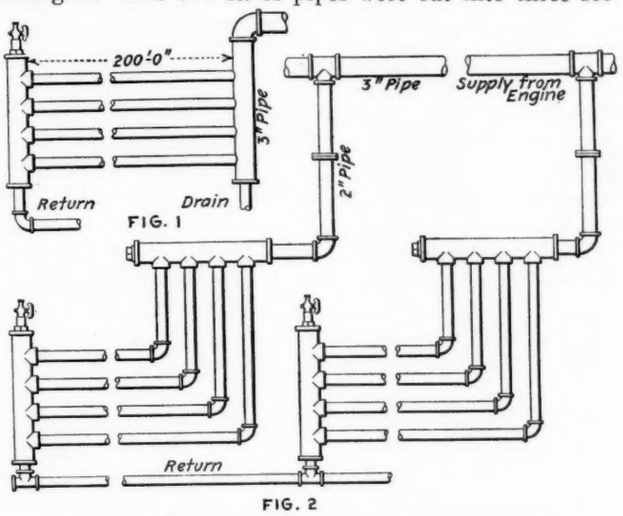


FIG. 2. PROPOSED ARRANGEMENT OF COILS

A separate drip is run from each section. To allow for expansion in the feed line to the coils the branch pipe is arranged as shown at *B*, Fig. 3. This system has been in use for about six weeks, and I believe that there will be no trouble this winter.

A short time ago a number of second-hand steam radiators were bought to be used in the new office, but in the lot there were none large enough to furnish sufficient heat for two rooms, each requiring 100 sq.ft. of heating surface. There were four radiators of 50 sq.ft. in the lot. So I decided to connect two of them together with a 2-in. close nipple. This did away with connecting each radiator separately to the supply and return lines.

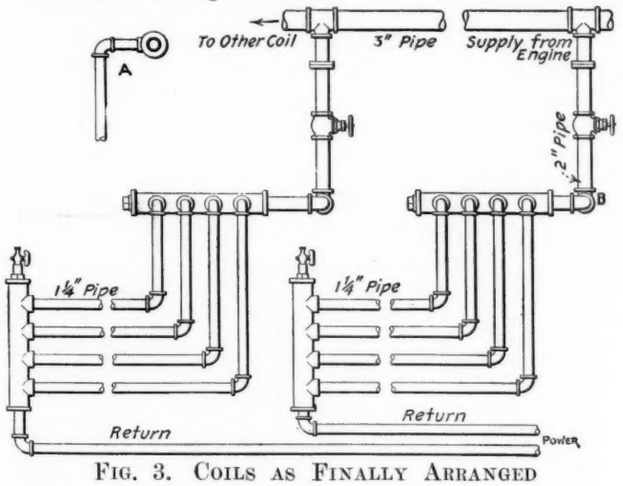


FIG. 3. COILS AS FINALLY ARRANGED

H. A. JAHNKE.

Milwaukee, Wis.

EDITORIALS

Commercial Building Heating

What are the reasons for the present practice in the heating of office buildings, stores and the like? The common tendency is to operate the power plants noncondensing, in the winter at least, and to use the exhaust steam under some pressure above atmospheric in the heating system. Greater back pressure on the engines means higher steam consumption, and so long as the extent of the heating requires the latter, it is justifiable. Then in a sense the engine is merely a reducing valve and the power generated a byproduct. If, however, the engine load is such that more than sufficient exhaust steam is available and some must go to waste, there is a corresponding loss of economy.

A compromise is the use of the vacuum-heating system, thus reducing the back pressure on the engine and consequently the steam consumption not only by lowering the initial pressure required on the heating system, but also by taking advantage of the condensing capacity of the radiation. This arrangement would be more successful were it not for the difficulty of keeping the heating system sufficiently tight. Where it is practically impossible to keep the entire heating system air-tight, it is not a difficult matter to maintain a vacuum of over twenty inches in a short exhaust pipe and the heater of a hot-water system. Where the power balances the heating in zero weather, it would be possible to run under considerable vacuum for five out of the seven months of heating and at full vacuum the other five months of the year. Blowing the exhaust to atmosphere from hundreds of horsepower at a rate approaching forty pounds per kilowatt-hour is by no means economical. A rather strong argument for a condensing plant in connection with hot-water heating as the solution of the problem, is put forth in an article on page 88. It is contended that this combination would reduce the steam consumption one-third, and by the use of a cooling tower the amount of water for the plant would be reduced in the same proportion.

With a condenser of the surface type, water unfit for boiler use might be circulated through the cooling tower and the water drawn from the city mains reduced to a negligible quantity. In a year's run the cost of water is an important item and another is the possible reduction in boiler capacity by operating condensing. These two items as well as the saving in steam consumption, must be balanced against the investment over and above the cost of an ordinary noncondensing, exhaust-steam-heating plant.

Where power is required to any extent in the building, the exhaust steam will be considerably in excess of the demands for heating. In such a case one of the units in the plant could be made to cover the heating and operate under partial vacuum, while the others could be operated at full vacuum. As a matter of fact this same arrangement might be applied to the ordinary noncondensing plant. That part of the load in excess of the heating might be operated condensing, or even at atmospheric pressure. There is no occasion to impose three pounds back pressure or perhaps more on the entire system, when a saving worth while in some cases might be effected.

There is much to be said on the other side, and it is hoped that those in a position to discuss this question authoritatively will do so. As stated in the article the discussion does not refer to plants carrying a normal load under two or three hundred kilowatts. There must be reasons why so many engineers favor the present commonest practice. Let us have them, as the subject is well worth a little attention.

❋

One Way to Know

Failures can be counted by hundreds in the immediate vicinity of most of us. Projects which looked promising to the individuals who had spent hours thinking about them, were failures from the start.

Engineers have found plant conditions such that it was evident, even to the inexperienced, that something was wrong, but what to do to remedy the trouble was a mystery. Remedies that could not possibly prevent the trouble have been tried, while at other times nothing was done, because the engineer did not know what to do.

In one instance the rear tubes of a return-tubular boiler began to leak. This was a preplexing experience to the engineer in charge, who was new to the work. He had no idea as to the cause, but was told it was because of an accumulation of scale on the rear head and around the tubes at the back end. As a matter of fact, scale did have something to do with the trouble, but it was mainly due to blowing down the boiler while under steam pressure, washing it out with cold water, refilling it and raising steam in the shortest possible time, sometimes not more than an hour being taken to do so.

This man did not know any better than to abuse the boiler, and instead of removing the scale and taking a longer time to generate steam from cold water, the scale was allowed to remain on the tubes and head, and steam generated in the quickest possible time. Now this engineer was ignorant concerning the damage he was doing the boiler, not because nothing had been published regarding the evil effects of scale, of hastily generating steam or of forcing the fires under a cold boiler, but because he had not read what had been published regarding these subjects.

In another instance a pump would not pick up water, due to a high suction lift and no foot valve on the suction pipe. It required the service of a pump man to remedy the matter, who put in a foot valve. The engineer knew where the trouble was, but did not know how to remedy it. Another case of not reading what had been published regarding the subject.

These two incidents bring us to the point at issue; lack of knowledge, due to lack of reading. Some engineers are like the small boy in the first grade of the day school, who wanted his father to write down a few prob-

lems in arithmetic. When the boy found that they were a little more difficult than those to which he had been accustomed, he threw down his paper, saying they were too hard and not what he wanted. Sums of two and two, etc., would have been easy, but useless, because the boy already knew them.

Are not many engineers in the same class with the small boy? Is it not a fact that they do not think it necessary or of advantage to themselves to read articles dealing with engineering subjects with which they are not familiar?

Do they realize that an article relating to some engineering features foreign to the plant they operate may be of such character that the information gained from reading it may be of much value in after years? There are many engineers who have profited by such reading long after the article had been destroyed and apparently forgotten.

In this age of progress the man who expects to keep pace with the times cannot expect to learn everything for himself by experience; he must take advantage of the published experiences of others. It will save mistakes, and much overtime and discouraging hard work.

❋

Should the Engineer Be Factory Fire Chief?

Due to the heavy losses of life and property by fire in recent years, the need of means, compulsory and volitional, for fire prevention, is justly emphasized.

When thousands of workers, most of them females, are housed in one, or at most, a few buildings and particularly if the product manufactured is highly inflammable, numerous and unobstructed exits, alarm systems, fire pumps and other fire defensive equipment, and regular fire drills become a necessity.

The factory fire chief who usually directs this part of the organization and cares for the mechanical and electrical equipment should, besides being a good organizer, be a man of mechanical training and ideas. So much of the fire preventive and fire-fighting equipment comes within the engineer's department that he, in many places, is selected by the management to act as factory fire chief. No doubt the selection is logical, for, besides being qualified to competently care for the necessary mechanical and electrical equipment, he is, generally, the best man to work out new devices and improvements which conduce to a higher effectiveness of the fire-fighting system.

The appointment of the engineer as factory fire chief has its disadvantages. The thing to remember is that he is responsible for the power plant and often his whole time must be devoted to such duties. Furthermore, the additional equipment for fire prevention and fighting increases his duties because he alone is capable of caring for such equipment. The proper care of sprinkler system, extinguishers, alarm systems, pumps, etc., is all that should be expected of the engineer in addition to his regular work.

Let someone with less exacting duties and with character and judgment equal to that of the engineer be appointed factory fire chief to take charge of the fire drills, etc. The logical relation of the engineer to this department should be as adviser regarding the necessary mechanical equipment. To expect him to care for a large plant and assume the functions of the factory fire chief, and maintain both departments in a state of high efficiency is too much. Where the plan is tried it is likely to result in both departments being too much neglected.

❋

Discussion of Engineering Subjects

In this issue, page (94) we print a letter from a contributor who tells of a progressive company that formed a reading club in its engineering department for the purpose of discussing articles that appear in engineering papers. The members are assigned to papers and make abstracts of articles most suited to the club's purpose. After the abstract is read and discussed it is filed for reference.

The many advantages of such a plan are at once apparent. Perhaps other companies will form such clubs if their engineers work toward that end. The letter reminded us chiefly of the deplorable lack of discussion on subjects valuable to every engineer by most engineering societies.

Among some societies composed mostly of the rank and file of practical power plant men, there is a dirth of such discussion that is positively inexcusable. After attending many meetings one gets the impression that the organization has entirely missed its fundamental purpose.

The social end of an engineering organization is of great importance, but if the bulk of attention is centered on this feature the charter ought to be revised to apply to a glee club. Every engineer, however competent, meets with perplexing experiences that are of interest and value to every other engineer. Many engineers are confronted with problems that they find it difficult to master without assistance. At the meetings and through the power-plant papers, these experiences and problems should be related and discussed so that practical benefit to a large number may come of them.

If more time was thus spent instead of taking up the evenings with parliamentary quibbles, and good, but too much entertainment, the purpose of the organizations would be better realized. It would seem a suggestion worthy of consideration that such organizations make it a practice of carrying out some such plan as that described by our contributor.

❋

Bourne's "Handbook on the Steam Engine," published in 1866, contains (page 154) the following interesting table:

At the atmospheric pressure, and starting at 212 deg. F., the following estimates of the latent heat of steam have been formed by the best authorities:

Watt	950	Despretz	955.8
Southern	945	Regnault	966.1
Lavoisier	1000	Fabre and Silbermann	964.8
Rumford	1008.3		

Regnault's estimate was then regarded as the most accurate. He is also credited with giving 965.7 as the latent heat of evaporation. Today the generally accepted value is 970.4, as given in the Marks & Davis steam tables.

❋

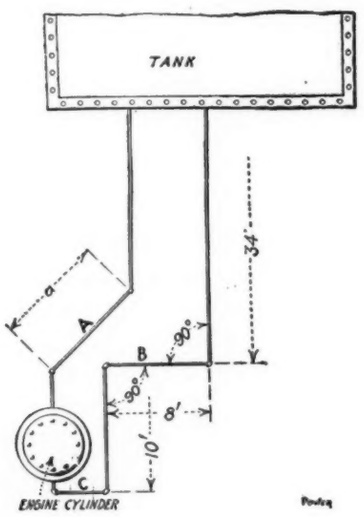
The index for the second half of POWER for 1912 will be mailed with the Jan. 28 issue.

READERS WITH SOMETHING TO SAY

Gas Engine Jacket Water Piping

A gas engine had to be cooled with water from a large tank 50 ft. above it. It was decided not to waste the water but to return it to the tank where the few added heat units would do no harm in the body of constantly replenished water. Since this tank would sometimes be nearly empty, it was not desirable to add an upstanding length of pipe to insure that the circulation should be always one way.

The instructions given to the pipe fitter were to install both rising and down pipes shaped as the pipe *A* so that the whole length of each pipe would have no horizontal length in it except the unavoidable length at *C*. Instead of doing so he connected them shaped as pipe *B*, which



CONNECTIONS FOR GAS-ENGINE JACKET WATER CIRCULATION

has a horizontal piece of several feet and with elbows at all turns. The down pipe *B* was left thus, but the rising pipe *A* was made larger, all its bends were made large and the length *A* was inclined as shown.

Assurances were given by some that the water could not circulate, though they could offer no reason why. When the engine began to run it upset their calculations entirely, for the circulation was more than sufficient. But it also upset my notions, for the pipe *B* was the hot pipe, and *A* was the supply, while water flowed into the top of the jacket and out at its base. This did not matter for the object sought was attained, although it did not last. Sometimes the circulation goes one way, at others it goes the opposite.

The larger pipe *A* was intended to help the warm water to get away freely, but the circulation seems to select either way indifferently, and I am by no means sure that the supposed wrong way around is not the better way for the cylinder, for it tends to a better cooling effect on that part of the cylinder toward which heat is supposed to tend, and on which the lubricating oil is least inclined to stay. The flow is throttled to keep the jacket thermometer at 120 deg., and thus we get the cooling effect we want, economize good softened water and save the usual steaming cylinder of the ordinary circulation system.

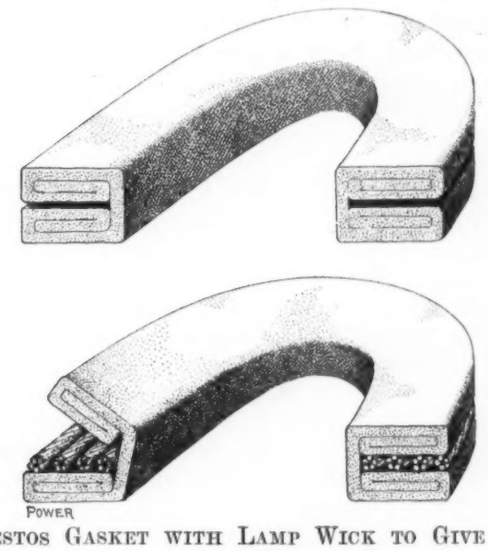
W. H. BOOTH.

London, England.

Using Rejected Packing

The accompanying illustrations are intended to show how a stock of asbestos gaskets which had been rejected as useless was made serviceable. The supply was bought with the intention of replacing the flat and tubular rubber gaskets that had formerly been used, the idea being to reduce the expense on this item. A section of this kind of gasket is shown below, but when they were applied every man and handhole plate leaked more or less and they had to be removed and rubber ones put in.

The chief was looking at that pile of gaskets one day when he got the right idea. He split one of the gaskets apart and wound several layers of asbestos wick packing between the layers and pressed the parts together again, a sshown in the lower illustration.



ASBESTOS GASKET WITH LAMP WICK TO GIVE IT SOFTNESS

The cushion thus created gave sufficient flexibility and elasticity to allow the hard layers of asbestos cloth to fill the indentations of the plate and ring and when they were applied the job was tight "for keeps" as the chief expressed it.

Now when the plates are removed for boiler cleaning the old layers of asbestos wick are pulled out and new ones inserted, and the gasket is liberally coated

with graphite. These gaskets may be used again and again, and can be depended upon to be tight. The expense of renewing the wick packing is hardly worth mentioning.

W. F. MEINZER.

Brooklyn, N. Y.

Engineers' Reading Club

Many engineers complain that they have not time to read the current power-plant papers, others say they cannot afford to subscribe to the magazine or paper they are most interested in, while some very foolishly believe that it is not necessary to read of the doings in up-to-date power plant work.

To overcome this objection and also to bring the men in closer personal contact, thereby promoting more congenial working conditions tending to better efficiency, the engineering department of a well-known company formed a club which meets bi-weekly for the purpose of discussing articles in engineering magazines. Each member of the club is assigned a paper or magazine and where there is much reading matter to be covered, two or more men are assigned to a paper to assist in the preparation of abstracts from articles.

These abstracts are intended to bring out the most essential features of the articles. A note relative to the author is also made. The abstracts are written on standard size sheets and after the meeting are put in the permanent file of the department where they remain available at all times.

The company makes it a practice to subscribe to many of the leading magazines, so the data are compiled at no expense to the club members and no more effort than any engineer might put forth in compiling data for his own personal use, not to mention the great advantage to be gained from the discussion.

MORGAN G. JOHNS.

Philadelphia, Penn.

Ashes Promote Pipe Corrosion

The use of ashes as a filling for trenches wherein are laid steam pipes or water pipes, whether galvanized or black iron, cannot be too strongly condemned. Unless the pipes are thoroughly insulated from the moisture prevailing in the earth surrounding them, serious and rapid corrosion of the pipe is sure to result. This fact does not seem to be generally realized, as in many industrial plants where pipes are laid throughout the yards, the ashes are dumped into the yards directly over the pipe lines. The result is that these lines must be taken up frequently and renewed.

In one plant of which I had charge bubbles of water and sand were noticed directly above where a pipe was located. This was a return pipe and had been installed previous to my coming to the plant. After excavating the pipe we found that several holes had been eaten in the top of it. This allowed the pipe to leak, but being a return pipe, there was often a vacuum in it, especially at night, when the plant was shut down. This allowed dirt and mud to be drawn into the pipe, which with ashes were sucked through the pipe and into the receiver, and finally drawn into the feed pump, getting under the valves and holding them off their seats, completely crippling the pump, scoring the sleeves in the water end and doing other serious damage.

At the time it was not realized just what had caused the pump valves and sleeves to wear so badly. Neither was it known just how the pipe had become so badly corroded. After the new pipe was put in, it did not last more than fifteen months, and we also experienced the same trouble with the receiver and pump. When the second pipe was put in it was thoroughly isolated from the surrounding soil by being put in a box filled with sawdust. The ashes were also removed from this place and deposited at another part of the yard where there were no pipe lines.

Another instance that seems to prove that ashes and moisture combined act as a severe corrosive agent, is that related by a friend of mine. While on top of one of the boilers one day, he saw steam coming up through the covering, which consisted of about three inches of ashes on top of the usual asbestos. Investigation revealed that the steam pipe above the boiler had been leaking and allowed water to drop down on the ashes, creating a chemical lye or something which had eaten a hole through the top of the boiler plate. The inspector was called and immediately reduced the allowable pressure from 110 to 40 lb., until repairs could be made.

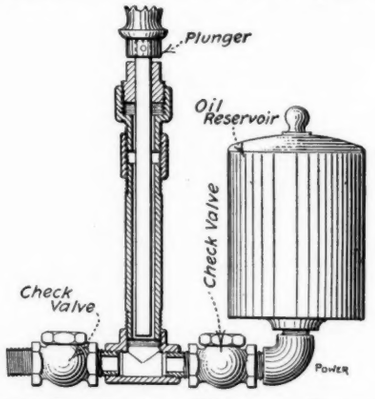
The leaking of water legs in boilers has been traced to wetting the ashes in the ashpit, and in some cases this has caused no end of patching below the grate.

A. C. WALDRON.

Revere, Mass.

Home Made Force Pump Lubricator

The following fittings can be found in almost any engine-room equipment and when put together, according



PUMP LUBRICATOR MADE OF FITTINGS

to the illustration, will make a serviceable oil hand-pump that can be attached to any engine cylinder:

one ¾x3-in nipple
one ¾x¾-in reducing coupling
one ¼-in. plug
one ¼-in. coupling
one ¼x¼-in. tee
one round iron rod ¼x5-in.
four ¼-in. close nipples
one ¼-in. ell
two ¼-in. check valves
one lubricator oil reservoir
one old file handle.

The plug should have a ¼-in. hole drilled through the top and can be used as the packing gland, and the reducing coupling as the stuffing-box.

FRED L. WAGNER.

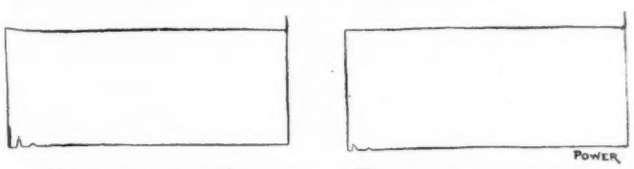
Chicago, Ill.

QUESTIONS BEFORE THE HOUSE

Pump Diagrams for Comment

In your issue of Oct. 15, you published three indicator diagrams taken from a vertical triple-expansion pumping engine 28, 54 and 80 by 60 in. with 30-in. plungers and having a capacity of 20,000,000 gal. The letter was written by John Burnes of Columbus, Ohio.

I enclose two cards taken from a cross-compound pump 20, 39 and 11½ by 16¼-in. stroke having a capacity of 3,000,000 gal. at 40 r.p.m. with 225-ft. elevation of



LOW-PRESSURE SIDE HIGH-PRESSURE SIDE

discharge. The suction lift is 14½ ft. An 80-lb. spring was used in the indicator producing the diagrams. I would like Mr. Burnes or other readers to criticise these diagrams and advise what I can do to improve the action of the pump.

Olean, N. Y. E. A. HOMER.

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Interesting Boiler Experience

Referring to the article appearing under the above heading in the Nov. 5, 1912, issue of POWER and signed by Thomas Sheehan, North Adams, Mass., I beg to state that while Mr. Sheehan's article describes the difficulty encountered, it does not correctly state the real cause of the difficulty, nor how it was overcome.

The facts in the case are that the load upon the Hoosac Tunnel power plant of the Berkshire Street Ry. has been, and still is, very irregular, varying from extremely light loads to considerable overloads, the latter lasting but a few moments, then going off almost entirely.

With the boilers, which are equipped with Taylor under-feed stokers, under fire, and generating only sufficient steam to operate the exciter units, and the main units very lightly loaded, the fires are comparatively dead. When the overload comes on, an automatic valve controlled by the steam pressure instantly opens the forced-draft-fan steam supply wide, starting up the turbine-driven forced-draft fans to their highest speed, and almost immediately bringing the fires on the stokers to a state of high incandescence. This is accompanied by a very sudden drop in steam pressure.

When the load goes off, the conditions are reversed, the fires being immediately deadened by the cutting off of the air supply, and it was originally the practice of the power-plant attendants to open all the doors on the boilers which they could reach, to rapidly cool the fires by admitting cold air over the fuel.

This entire cycle imposed about as severe conditions upon the boilers in question as it was possible to obtain, and conditions which are more extreme than any now known to the writer.

As Mr. Sheehan states, tube failures were not at first encountered; but after the plant had been in operation for a time, tube failures began, and grew more and more frequent. This condition seemed to be entirely beyond analysis by any of the power-plant crew, and it was not until the manufacturers were called into consultation that it was found that the tubes in question were covered with a scale from $\frac{3}{16}$ to ¼ in. thick. The feed water from which this scale was formed came from artesian wells near the plant, and analyses of the scale showed its composition to be as follows:

	Per cent.
Silica	4.59
Oxides of iron and aluminum	2.00
Calcium sulphate	25.00
Calcium carbonate	1.30
Magnesium hydrate	67.11
Total	100.00

The silica and iron and aluminum oxides form scale only in the presence of other ingredients. The calcium sulphate precipitates out at boiler pressure and temperature and mixes with the other material, forming a hard scale which is a very poor conductor of heat. The calcium carbonate forms a bulky scale which is not very hard. The magnesium hydroxide in combination with calcium sulphate forms a hard, stony scale, but, in this case, owing to the large excess of magnesium hydroxide, the scale formed is rather soft and chalky.

What probably occurred inside the boiler with the operating conditions as experienced was as follows:

The specific gravity of the magnesium compounds being near that of the water, these compounds were held in suspense for some time, gradually settling during the light-load periods when the circulation in the boilers was not active, and, owing to the slight inclination of the front tubes, these scale-forming compounds would naturally adhere to the side of the tubes next to the fire. With the recurring variations from very light load to overload the scale above mentioned, $\frac{3}{16}$ in. or more in thickness, adhered to the tubes, and when under the overload conditions the fire was suddenly urged to extreme activity, the high temperature imposed on the outside of the tubes would cause the metal to become overheated, and the tubes to bow toward the fire, as indicated by the illustration in Mr. Sheehan's article.

If there had been a constant load of some fair size upon the boilers, and no comparatively frequent periods of considerable duration of extremely light load, it is probable that the circulation would have carried the scale-forming particles into the back sections where the circulation is comparatively inactive, and these particles would have been precipitated in the rear units, dropped into the mud drums, from which they would have been removed at intervals through the blow off. This would also have been true if the water had been of a different nature, and impurities ordinarily encountered except magnesium had been present, so that such impurities

would not have been so readily carried forward by the circulation to be left in the forward tubes during the periods of comparative inactivity.

The first care of the station operators should have been to examine the boilers internally, and determine whether their internal condition was satisfactory. The scale formed upon the tube surfaces was an excellent insulator to the passage of heat. As the boilers have since been cleaned, and treatment of the water has been instituted, the troubles referred to have disappeared.

The plant is at present operating quite satisfactorily under conditions sufficiently severe to probably make a great deal of trouble with any apparatus which is not especially adapted for handling the most extreme variations of load in the shortest possible time.

New Haven, Conn. E. S. Cooley.

The Allis-Chalmers Engine

It was with pleasure that I read the article in the issue of Sept. 17, on the new Allis-Chalmers engine. I am particularly interested because the chief features of this engine, which lead to the excellent results (so far as steam consumption is concerned), are exactly copied from the construction of the Rice & Sargent engine, which Mr. Sargent and myself designed about nineteen years ago, and which has been on the market since that time with excellent success.

I refer to the double-ported steam valves located close to the cylinder port, and the double-ported exhaust valves, partly projecting into the cylinder, but sufficiently beyond the piston travel to be out of danger of contact therewith. Also to the steam valves moved by direct lever motion in contrast to the usual wristplate motion, thereby permitting the engine to cut off as late as three-quarters of the stroke; whereas the wrist motion limits cutoff to between 0.4 and ½ stroke, while the exhaust valves are moved by a separate eccentric and coupled to the usual wrist motion.

These are the essential features of the Rice & Sargent engine, and it is gratifying that after 19 years the Allis-Chalmers Co. has adopted these points.

So far as I can ascertain from an inspection of the article, the only novel feature about the engine is the governor, and this departure from the Rice & Sargent design would hardly seem to be warranted, as the governing mechanism is more complicated than the inertia governor used by us, without being so sensitive in providing against variations in speed.

One other point which was provided for in the Rice & Sargent engine, which does not seem to have been incorporated in the Allis-Chalmers machine, so far as the drawings show, was provision for expansion of the steam cylinder without throwing it out of line, at the same time without introducing any stresses in the foundation or bedplate. I commend this point to the designers of the Allis-Chalmers company.

West Lynn, Mass. Richard H. Rice.

State Boiler Inspection

The editorial under this heading in the Dec. 3 issue was read with much interest and it brought out some very good points. There has been a large number of serious boiler explosions in the last few years and if the daily papers would show them up as Power does, the public would soon demand protective laws. But there was one statement in the editorial that I wish to take exception to. It was stated that Massachusetts and Ohio were the only states having such laws and enforcing them. Montana also has very good boiler laws and competent inspectors to see that they are enforced.

Each stationary boiler in this state has to be inspected once during each year. The inspectors are very careful and thorough in their work. I worked in one plant where they required the pressure to be reduced from 125 to 110 lb., and the boilers were not over seven years old. They also ordered the steam pipes, traps and blowoff pipes kept in good condition. I have been in Montana eight years and have not heard of a serious explosion in that time. Any man in charge of boilers who has to attend to the water must have a third-class engineers' license. To be able to take the examination he must have had at least one year's experience in firing or running steam boilers or engines. To get a first-class license an applicant must have had three years' experience.

Some engineers complain about state boiler inspection and license laws, but when a man steps into a plant which has been inspected by a competent inspector he feels safer than he would if the plant had never been inspected.

Harold J. Wilkinson.

Livingston, Mont.

Stick Phosphorus for Flue Gas Analysis

The point made by G. W. Munro in the Dec. 3 issue about washing off the sticks of phosphorus, while good, is not a thing requiring frequent performance. Taking 100-c.c. samples of free air, 100 such samples would contain about 2100 c.c. of oxygen, which would weigh 3.003 grams. This would burn with 3.879 grams of phosphorus to P_2O_3, and with 2.327 grams of phosphorus to P_2O_5 (in moist air, such as exists in a gas apparatus, the combustion product is a mixture of the two). In the first case only 1.126 c.c. of water would be necessary to convert the P_2O_3 to HPO_2; in the latter only 0.675 c.c. of water to convert the P_2O_5 to HPO_3, while the ordinary phosphorus pipette holds about 120 c.c. of water. Flue gas never carries 21 per cent. of free O_2.

As to A. H. Gill's objections, the ordinary analyst should not attempt to make his own phosphorus sticks but should buy them. The change from white to red phosphorus ("the tough leathery skin") is slow except in direct sunlight. Unless a hole be broken in the pipette the leakage of air will not be rapid enough to cause the phosphorus to melt; a crack will not do it.

If Mr. Gill has any quantitative results on the formation of ozone by moist oxidizing phosphorus, I wish he would publish them. I have never seen anything but qualitative tests showing that ozone could be formed under those conditions, and always thought that traces only were made, which were not quantitatively comparable with the inaccuracy of the various determinations arising from other sources.

This I know, that I have seen carbon monoxide reported many times when it did not exist, through the use of an old pyrogallate solution which did not absorb the oxygen, with subsequent absorption of this O_2 as CO.

Donald M. Liddell.

Elizabeth, N. J.

INQUIRIES OF GENERAL INTEREST

Variation of Water-level—Does the water stand still in a boiler when the engine is running, or does it move up and down in the glass?

E. D. P.

When the boiler steam space is small in proportion to the size of the engine cylinder, the gage-glass may show a variation in water level at every stroke of the engine.

Cylinder Trouble—Why does water in a steam cylinder cause trouble?

P. D.

If there is water in a cylinder more than sufficient to fill the clearance space at the end of the stroke, since it cannot escape after the exhaust valve closes, damage will result to the cylinder as by breaking or knocking out the cylinder head because water is nearly incompressible.

Determining Rivet Sizes and Pitch—What determines the sizes of rivets and pitch?

C. H.

The selection of rivet sizes is largely a matter of convenience and practical experience. The following are used in average good practice:

½-in. thick plate or strap	11/16-in. rivets
5/8-in. thick plate or strop	¾-in. rivets
⅝-in. thick plate or strap	⅞-in. rivets
¾-in. thick plate or strap	1⅛-in. rivets
½-in. thick plate or strap	1-in. rivets

Having found the size, the pitch is so selected as to obtain a joint of highest efficiency. This must be a joint the strength of which will be the highest percentage of strength of the solid plate for a unit length of joint. "Rules Formulated by the Massachusetts Board of Boiler Rules," pages 13 to 19, furnishes a reliable method of calculating joint efficiency. To find the efficiency of a butt and double strap joint, see POWER of Dec. 31, 1912, page 985.

Cylinder Compression—What is the meaning of compression as applied to the steam-engine cylinder?

L. M.

If by the compression as applied to the cylinder is meant the compression of the steam in the cylinder, the word as usually used signifies the compression of the steam, which is left in the cylinder when the exhaust valve closes, into the clearance space by the completion of the stroke by the piston. Such compression is used to cushion the engine to absorb to some extent the momentum of the moving parts so as to change the direction of pressure upon the pin gradually and also to fill the clearance space with the denser, hotter and higher-pressure steam.

Reducing Piston Clearance—What advantage would there be in reducing the piston clearance ¼ in. on each end of the cylinder of a 20x42-in. Corliss engine, the present clearance being ⅞ in.?

M. J.

The saving effected will depend on the volume of present total clearance in the cylinder and steam passages; that is, when the piston is at the end of its stroke. The only way to reduce the clearance is by increasing the thickness of the cylinder heads inwardly or that of the piston. The improved economy would depend on the size of the load and the indicator diagram the engine can make at present. Reducing the clearance ¼ in. would neither pay for the trouble nor leave safe clearance for the adjustment of the connecting rod and the crosshead.

Least Diameter of Rope Pulley—Would a 17-in. diameter sheave be suitable for a 1-in. manila-rope drive where the rope is driven by a 12-ft. diameter flywheel pulley running at 80 r.p.m.?

A. S.

The velocity of rope, driven as proposed, would be about 3000 ft. per min., and for that speed the least diameter of sheave for 1-in. diameter manila rope should be not less than 26½ in. If made smaller, the rope would wear rapidly. For general work it is found that 36-in. diameter is the smallest size practicable for use with 1-in. manila rope for all speeds. The causes of many failures and much trouble in rope driving are due to the use of too small pulleys for the size of rope and tension carried.

Engine Out of Balance—Is an engine out of balance if, when placed on either head or crank centers with the valve stem and piston-rod packing removed and all working parts connected, the crank-pin rotates to the bottom of the crank case?

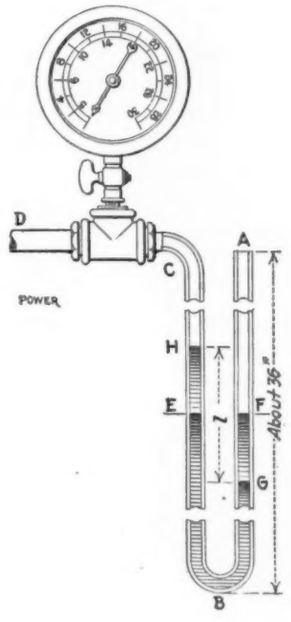
G. R. F.

To determine whether the crank settles in standing balance of the engine on account of the weight of the connecting rod, detach the crank end of the connecting rod and vibrate the flywheel by hammer strokes square against the side of the wheel. If the wheel stands balanced in every position the crank is in standing balance. The lack of balance when the rod is connected up is due to the weight of the connecting rod not being balanced in standing balance. The engine may not be in standing balance, but may be in running balance. Running balance can only be adjusted by placing different weights in different positions on the flywheel when the engine is running at its proper speed. The weighting thus required is not generally suitable for standing balance.

Testing a Vacuum Gage—What is the best way to test a vacuum gage?

H. F.

The best way to test a vacuum gage is to compare it with a glass U-tube mercury gage as indicated in the sketch. The bent tube ABC, having about ⅜-in. bore, is connected by suitable fittings to the pipe or nipple D, and the latter is connected with an air pump or condenser. The gage to be tested is placed on a tee. The U-tube should be about 36 in. over all and should be about half filled with mercury. When there is a partial vacuum made at D the atmospheric pressure acting on the surface of the mercury in the open tube AB, being greater than the pressure acting on the surface



of the mercury in the tube CB, the mercury at the original level EF will fall in AB, as to G, and rise in CB, as to H, and the difference of level between H and G as indicated by the dimension l, measured in inches, will be the "inches of vacuum" which the vacuum gage should indicate. While most manufacturers of vacuum gages are equipped with a U-tube mercury gage, they generally make comparisons with another gage, known to be correct with the U-tube gage. For testing a vacuum gage at a plant not equipped with a mercury gage, the usual practice is to compare the gage to be tested with one considered to be correct.

ENGINEERS' STUDY COURSE

Logarithms—Part II

As we learned in our last lesson, the logarithm of a number consists of two parts: an integral part and a decimal part, the integral part being called the *characteristic,* and the fractional part called the *mantissa.*

Rule 1. *The characteristic of the log of a number greater than unity is less by 1 than the number of integral places in the number and is positive.*

Thus the characteristic of the log of 48,226 is 4.

Rule 2. *The characteristic of the logarithm of a fraction or a number less than unity is greater by 1 than the number of ciphers immediately after the decimal point and is negative.*

From this rule we see, as learned in our last lesson, that the characteristics of logs of numbers below one are negative. From 1 to 9 they are 0 + a decimal fraction; 10 to 99 they are 1 + a decimal fraction; 100 to 999 they are 2 + a decimal fraction; 1000 to 9999 they are 3 + a decimal fraction, and so on. Study this paragraph, as it must be *memorized.*

$$1000 = 3$$
$$100 = 2$$
$$10 = 1$$
$$1 = 0$$
$$0.1 = \bar{1}$$
$$0.01 = \bar{2}$$
$$0.001 = \bar{3}$$

In logarithmic tables the characteristic is omitted and the mantissa only is given, usually without the decimal point before it, it being understood that it is a decimal. Most logarithmic tables, however, have a table giving the logs complete of numbers from 1 to 100 inclusive. Such a table is given in Table No. 1.

A page of the logarithmic tables of Vega are given in Table 3. They are carried to the seventh decimal place.

Use of Logarithmic Tables

To find the logarithm of a number containing one or two figures, such as

$$\log 8.5 = 0.929419$$
$$\log 0.85 = \bar{1}.929419$$
$$\log 0.085 = \bar{2}.929419$$

Referring to Table No. 1, under column "N.," find 85; the log of which is 1.929419. The mantissa for 8.5 will be the same but as the characteristic of numbers between 1 and 10 is 0 we strike out the characteristic 1 and substitute a cipher. The log of 0.85 is negative, i.e., less than zero by 1 because there is no cipher immediately after the decimal point (see rule No. 2); therefore, the characteristic of its log is negative, but the mantissa is again the same; hence it is expressed as 1.929419. Notice the minus sign over the characteristic. The log of 0.085 is negative, i.e., less than zero by 2; according to rule No. 2 the characteristic of the log of a decimal fraction is greater by 1 than the number of ciphers immediately following the decimal point. Here there is one cipher so the characteristic is $\bar{2}$ and the mantissa still the same.

To find a log of a number containing three significant figures. In the column headed "No.," find the number. In a horizontal line with it and under the column headed "0," find the mantissa. Prefix the required characteristic.

Table No. 1

Logarithms of Numbers from 1 to 100.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342423	42	1.623249	62	1.792392	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799341	83	1.919078
4	0.602060	24	1.380211	44	1.643453	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653213	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431364	47	1.672098	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944483
9	0.954243	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954243
11	1.041393	31	1.491362	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.531479	54	1.732394	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740363	75	1.875061	95	1.977724
16	1.204120	36	1.556303	56	1.748188	76	1.880814	96	1.982271
17	1.230449	37	1.568202	57	1.755875	77	1.886491	97	1.986772
18	1.255273	38	1.579784	58	1.763428	78	1.892095	98	1.991226
19	1.278754	39	1.591065	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	2.000000

Table No. 2

No.	0	1	2	3
570	75,587	75,595	75,603	75,610
571	75,664	75,671	75,679	75,686
572	75,740	75,747	75,755	75,762
573	75,815	75,823	75,831	75,838
574	75,891	75,899	75,906	75,914

Thus, referring to the above partial table, find the log of 574.

$$\log 574 = 2.75891$$
$$\log 57.4 = 1.75891$$
$$\log 0.0574 = \bar{2}.75891$$

From what we have just learned we know why the characteristics change for the changes in value of the given number.

To find the log when the number contains four figures. In the column headed "No.," find the first three figures. On a horizontal line with the figures and in the column containing the fourth figure, find the mantissa. Prefix the required characteristic. Thus

$$\log 5712 = 3.75679$$
$$\log 5.712 = 0.75679$$
$$\log 0.05712 = \bar{2}.75679$$

In the above example the first three figures are 571, the fourth is 2, so in the column headed "2" and on a line with 571, find the mantissa, 75,679. According to Rule 2 we see that the characteristic of the log of 0.05712 is $\bar{2}$ because there is one cipher after the decimal point. Vega's tables give logs of four-figure numbers directly.

To find the logarithm of a number containing more than four figures, we find the first four figures in the column "N," Table No. 3, and the last in the horizontal line at the top. The last four figures of the logarithm will be found where the horizontal line, correspond-

ing to the first four figures of the number meets the vertical line—corresponding to the fifth figure. The first three figures of the logarithm are in the column headed "0," and are common to all the figures in the same horizontal line. Where these are not given on the horizontal line, the previous three figures must be taken, except when the first of the last four figures is marked with a line above it, in which case the first three figures of the log are those that occupy that relative position in the next horizontal line below.

Example: Number 31,406, log 4.4970126.

Find the log of 31,328. The first four figures, 3132 are found in column "N." The last or 8 is found under 8 at the top of the table. The last four figures of the log are, according to the instructions just given, 9327. The first three figures are in the column "0" and are 495. Now we have the mantissa complete, which is 4959327. The characteristic, though not given, is seen to be 4, because the given number is over 10,000. Therefore, the log of 31,328 is 4.4959327.

To find the log of 31,333. Here the last four figures of the mantissa are 0020 and the first cipher is marked with a line, thus $\bar{0}$; hence they are to be combined with 496, which gives 4960020 as the mantissa, the characteristic being 4. Therefore, the log of 31,333 is 4.4960020. Suppose we wanted to find the log of 31,333.73; the difference between the logs of the two whole numbers of five figures each, between which the given number lies, must be multiplied by the decimal fraction and the product added to the log of the smaller whole number. Taking the number given, 31,333.73. This lies between 31,333 and 31,334, the logs of which differ by

$$0.158 - 0020 = 138$$

We multiply

$$138 \times 0.73 = 101$$

Notice that the decimal part of the product is rejected and the last figure of the integer part is increased by 1 when the rejected part is greater than 0.5.

Adding 101 to the log of 31,333 we have

$$4.4960020 + 101 = 4.4960121$$

for the log of 31,333.73. To facilitate this multiplication nearly all logarithmic tables contain small additional tables in the column headed "P.P." (proportional parts), Table 3, which for each of the differences of the numbers on that page gives the several tenths from which the hundredths, thousandths, etc., may be easily found.

In our last example, under the table headed "138," in column "P.P.," we get

For 0.7	96.6
For 0.03	4.14
	100.74

We reject the decimal fraction as before. We also moved the decimal point over one place to the left in the number 41.4 to correspond with the two decimal places in the number 0.03.

Given a logarithm, required the corresponding number. In the table, find the first three figures of the given log. Next find the remaining four figures in some one of the columns headed "0," "1," "2," "3," etc. Having found the log in the table, follow the horizontal line on which it is located toward the left, and find in column "N" the first figures of the number and prefix these to the figure found at the top of the column in which the log was found.

Given log 4.4980071, to find the corresponding number. The first three figures of the fractional part of the log appear in column "0," and the last four in column "8," but in the next horizontal line above, because in this example $\bar{0}$ occurs, as was explained about numbers with minus signs over them. The number corresponding to the log is therefore found to be 31,478.

For another example, suppose the log to be 4.4976414. We find that this log lies between those for 31,451 and

TABLE No. 3.

48

N.	0	1	2	3	4	5	6	7	8	9	P. P.
3100	491 3617	3757	3897	4037	4177	4317	4457	4597	4738	4878	
01	5018	5158	5298	5438	5578	5718	5858	5998	6138	6278	
02	6418	6558	6698	6838	6978	7118	7258	7398	7538	7678	
03	7818	7958	8098	8238	8378	8517	8657	8797	8937	9077	
04	9217	9357	9497	9637	9777	9917	0057	0196	0336	0476	1 14.1
05	492 0616	0756	0896	1036	1175	1315	1455	1595	1735	1875	2 28.2
06	2015	2154	2294	2434	2574	2714	2853	2993	3133	3273	3 42.3
07	3413	3552	3692	3832	3972	4111	4251	4391	4531	4670	4 56.4
08	4810	4950	5090	5229	5369	5509	5648	5788	5928	6068	5 70.5
09	6207	6347	6487	6626	6766	6906	7045	7185	7325	7464	6 84.6
3110	492 7604	7744	7883	8023	8162	8302	8442	8581	8721	8861	7 98.7
11	9000	9140	9279	9419	9558	9698	9838	9977	0117	0256	8 112.8
12	493 0396	0535	0675	0815	0954	1094	1233	1373	1512	1652	9 126.9
13	1791	1931	2070	2210	2349	2489	2628	2768	2907	3047	
14	3186	3326	3465	3604	3744	3883	4023	4162	4302	4441	
15	4581	4720	4859	4999	5138	5278	5417	5556	5696	5835	
16	5974	6114	6253	6393	6532	6671	6811	6950	7089	7229	1 14.0
17	7368	7507	7647	7786	7925	8065	8204	8343	8483	8622	2 28.0
18	8761	8900	9040	9179	9318	9457	9597	9736	9875	0015	3 42.0
19	494 0154	0293	0432	0571	0711	0850	0989	1128	1268	1407	4 56.0
3120	494 1546	1685	1824	1964	2103	2242	2381	2520	2659	2799	5 70.0
21	2938	3077	3216	3355	3494	3633	3773	3912	4051	4190	6 84.0
22	4329	4468	4607	4746	4885	5024	5164	5303	5442	5581	7 98.0
23	5720	5859	5998	6137	6276	6415	6554	6693	6832	6971	8 112.0
24	7110	7249	7388	7527	7666	7805	7944	8083	8222	8361	9 126.0
25	8500	8639	8778	8917	9056	9195	9334	9473	9612	9751	
26	9890	0029	0168	0307	0445	0584	0723	0862	1001	1140	
27	495 1279	1418	1557	1695	1834	1973	2112	2251	2390	2529	1 13.9
28	2667	2806	2945	3084	3223	3362	3500	3639	3778	3917	2 27.8
29	4056	4194	4333	4472	4611	4750	4888	5027	5166	5305	3 41.7
3130	495 5443	5582	5721	5860	5998	6137	6276	6415	6553	6692	4 55.6
31	6831	6969	7108	7247	7385	7524	7663	7802	7940	8079	5 69.5
32	8218	8356	8495	8634	8772	8911	9049	9188	9327	9465	6 83.4
33	9604	9743	9881	0020	0158	0297	0436	0574	0713	0851	7 97.3
34	496 0990	1128	1267	1406	1544	1683	1821	1960	2098	2237	8 111.2
35	2375	2514	2653	2791	2930	3068	3207	3345	3484	3622	9 125.1
36	3761	3899	4038	4176	4314	4453	4591	4730	4868	5007	
37	5145	5284	5422	5560	5699	5837	5976	6114	6253	6391	
38	6529	6668	6806	6945	7083	7221	7360	7498	7636	7775	
39	7913	8052	8190	8328	8467	8605	8743	8882	9020	9158	
3140	496 9296	9435	9573	9711	9850	9988	0126	0265	0403	0541	1 13.8
41	497 0679	0818	0956	1094	1232	1371	1509	1647	1785	1924	2 27.6
42	2062	2200	2338	2476	2615	2753	2891	3029	3167	3306	3 41.4
43	3444	3582	3720	3858	3996	4135	4273	4411	4549	4687	4 55.2
44	4825	4964	5102	5240	5378	5516	5654	5792	5930	6068	5 69.0
45	6206	6345	6483	6621	6759	6897	7035	7173	7311	7449	6 82.8
46	7587	7725	7863	8001	8139	8277	8415	8553	8691	8829	7 96.6
47	8967	9105	9243	9381	9519	9657	9795	9933	0071	0209	8 110.4
48	498 0347	0485	0623	0761	0899	1037	1175	1313	1451	1589	9 124.2
49	1727	1865	2002	2140	2278	2416	2554	2692	2830	2968	
3150	498 3106	3243	3381	3519	3657	3795	3933	4071	4208	4346	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

31,452 and that the difference between log 31,451 and the given log is

$$6414 - 6345 = 69$$

Now in the table headed "139" in the column "P.P." of proportional parts, find that 5 gives a difference of 69; therefore the corresponding number to log 4.4976414 is 31,451.5.

Suppose we are given the log 4.4956443. The nearest log to this one is 4.4956415, to which corresponds the number 31,307. The difference between it and the next greater log 4.4956553, is

$$6553 - 6415 = 138$$

while the difference between it and the given log is

$$6443 - 6415 = 28$$

The figures following the first five places are found from the table of proportional parts, headed "138." Take from it the next figure 2, corresponding to 27.6, which

is next inferior to 28; subtracting 27.6 from 28 gives 0.4. Take this 10 times, which gives 4, which corresponds to 0; taking it 100-fold, which is 40, which is opposite to the next inferior number, which is also 27.6 and being opposite 2, this number (2) becomes the eighth figure of the number. Now the difference between 40 and 27.6, which is 12.4, is increased tenfold, giving 124 which, being opposite 9, shows that 9 is the last figure of the number, 313,072,029. Since the log has an index or characteristic of 4, the decimal point (see rule 1) must be put after the fifth figure. The number now becomes 31,307.2029.

ANSWERS TO LAST WEEK'S QUESTIONS

(1) To quickly and conveniently find the roots and powers of numbers.

(2) 10.

(3) Numbers between 1 and 10; between 10 and 100; between 100 and 1000; between 1000 and 10,000; between 10,000 and 100,000.

(4) (a) Add the logs of the multiplicand and multiplier to find the log of the product. (b) Subtract the log of the divisor from the log of the dividend to find the log of the quotient. (c) Multiply the log of the number by the exponent to find the log of the required power. (d) Divide the log of the given number by the index of the root (2 for the square root, 3 for the cube root, etc.), to find the log of the required root.

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A Record in Plant Construction

An instance of rapid power-plant construction has recently come to light in connection with the extension to the Jordan steam station of the Utah Light & Ry. Co., at Salt Lake City, by Westinghouse, Church, Kerr & Co., of New York.

The original station was designed and built by the same engineers in 1910 and consisted of an 8500-kw. single-unit steam turbine installation intended to supplement the several hydro-electric plants of the company and also to form a nucleus for such steam-generating equipment as might be required later.

The new work practically duplicates the former plant and comprises in general a brick and steel building 100x 60 ft., the walls resting on a pile concrete mattress consisting of 36-ft. piles overlaid with about 3 ft. of concrete. The boiler equipment consists of Stirling boilers fitted with Roney stokers and served by a 225-ft. radial brick stack. The turbine equipment consists of one Westinghouse-Parsons unit of 8500 kw. capacity delivering 60-cycle, three-phase current at 4400 volts. Thus the total capacity of the plant (original and extension) is 17,000 kw.

The rapidity with which the work was carried on may be seen from the following: On Mar. 27, 1912, authorization was received to design the extension. Five days later sufficient progress had been made so that the main unit, the boilers, condenser, stack, heater, stokers and piles had been purchased. On Apr. 6 excavation was begun and two weeks later the first piles were driven. On Aug. 26—152 days after authorization—the plant was put under commercial test.

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The strength and brittleness of steel plates as affected by various boiler waters are being investigated at the engineering-experiment station of the University of Illinois.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Water goes over the spillway of the Gatun dam on the Panama Canal at the rate of 16,000 cu.ft. per sec. This spillway is about 70 ft. high—"Leslie's Weekly." Our little spillway is only 10 in. high, but think of— Well, you're reading it, and our modesty forbids our saying any more.

Our Uncle Sam, as head of his large and growing family, has tucked away in his jeans the tidy little sum of $3,350,727,580. Including you and me, the family is 96,496,000 strong. Divided up equally, each has $34.72 to his credit. See you tonight after the whistle blows and we'll hot-foot it over to Washington and get ours before the crowd is on.

Rechid Pasha, made timorous by Bulgarian victories, has goulashed his chances as an efficiency engineer, and wants to go home. Don't feel so wretched, Rechid. Pshaw, pasha, buck up; you know by this time that the Bulgarian hug has put the Turkey trot in the scrap heap.

If you were an editor, and sweated over the "Inquiries" page in an endeavor to be the correct answer to the sum of all human knowledge, and spent two whole days answering "Old Subscriber's" inquiries, and then found you had overlooked his postscript telling you to stop his paper as his fireman took it and he'd read his, and— Talk about reciprocal relations, old chap; you can jolly well believe this blighter is the absolute limit, eh what?

The alleged report of the formation of a "water-power trust" has apparently incited the glue makers to go and do likewise. If the glue people once get together, they'll stick all right. Oh, Tessie, wouldn't this be just too perfectly mucilaginous for anything?

Cheers for the New England Society, says "Leslie's Weekly," for wishing J. Pierpont Morgan and Joseph H. Choate "good health and many happy years to come." Our field keeps us out of the financial and legal zones, but here's three cheers and a tiger for anyone who will say a good word for his fellows.

Great have been the researches of the scientists! Based on calculation of radioactive phenomena, that dear old lady Mother Earth has reached her 711 millionth birthday, and is still going strong. Over in Sussex, England, a brace of high foreheads have unearthed the oldest known skull. Here's your opportunity. Where is the thickest known skull? No beans-in-the-jar guesswork. A handsomely bound copy of "Thick Craniums I Have Known" will be given the first discoverer. This contest is limited to "Power" subscribers.

A "scrap" expert has been added to the navy personnel. At first thought, this title may suggest its appropriateness in a body whose main duty is to scrap a heap in wartime. But this expert has been set to reclaiming materials thrown into the scrap heap, as the government hopes to save considerable through this new economy. This expert has a fighting chance to win out.

Some "food for thought" has been served us in a pamphlet written by a prominent banker entitled "Who Shall Control Our Financial Destiny?" Friend banker said the question has three possibilities. We took it home, showed it to friend wife, and she settled the control right off the handle. She also leaves the possibilities to the future; has all she can do to feed and clothe our "realities." Truly, the hand that agitates the cradle dominates!

Mexican rebels have been shooting down the power-transmission lines and cutting off the light service in Mexico City. A little ginger is an incentive to good results, but the red pepper in the chile con carne is overdoing the thing in Mexico apparently.

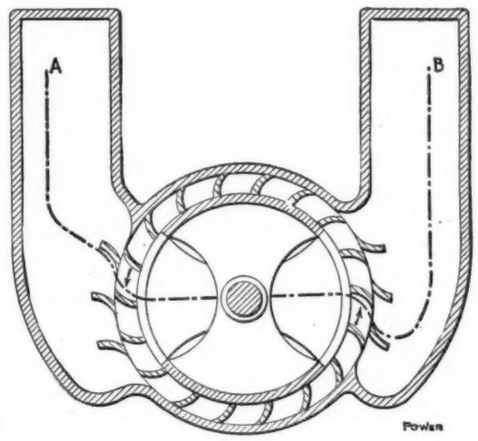
It beats all, the blows aimed at the privileges of us working people. Along comes the U. S. Public Health Service and tells us to cut out the fingerbowl; it's full of germs! Next thing, brother, we will be told to avoid the manicure—and some of them are so darn attractive it is that we should worry!

We wish we had—for this column only—the exclusive services of that newspaper reporter who thus sums up the reason for a large fire in a Western city: "The fire had its origin from an electric wire on a hot journal of one of the immense boilers, causing an explosion of the boilers." Then, all at once, the sun went down and the stars came out!

A Gas Propelled Water Turbine

One manifestation of the striving for the application of the internal combustion principle to a motor of the turbine type is the proposition illustrated in the accompanying sketch reproduced from our English contemporary, *Engineering*, submitted by James Dunlop, of Glasgow.

The turbine casings and the explosion chambers *A* and *C* are filled with water until it reaches to about half the



A Gas-propelled Water Turbine

height of each chamber. By alternate explosions in each chamber the water is caused to operate through the turbine and in doing so to maintain continuous rotation of the turbine wheel. The dotted lines indicate the course of the water and the direction of the driving reactions. For a given number of impulses, any desired speed of revolution may be obtained by varying the diameter of the wheels or the arc of circumference made effective. For high speeds entrance would be around the whole circumference of one wheel and exit around the circumference of a similar wheel. Axial-flow wheels might be similarly arranged.

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The Myriawatt

At a joint meeting of the Standards Committee of the American Institute of Electrical Engineers, and of a committee specially appointed for the conference by the American Society of Mechanical Engineers, on Dec. 13, 1912, at the Engineering Societies Building, New York, the following resolutions were unanimously adopted, and have been duly reported to the governing boards of the two above mentioned engineering societies:

WHEREAS, the "myrowatt" or "myriawatt" was suggested by H. G. Stott as a convenient unit of power only 2 per cent. larger than the most recently determined values of the "boiler horsepower," and,

WHEREAS, a paper* setting forth the advantages of the use of the "myriawatt" as a unit of power in dealing with the performance of steam boilers, steam engines, gas engines, steam and water turbines was read by Messrs. H. G. Stott and Haylett O'Neill before the annual convention in Boston of the American Institute of Electrical Engineers in June, 1912, was discussed, and was published in the *Proceedings* of the institute, and

WHEREAS, the American Society of Mechanical Engineers has appointed a special committee to confer with the Standards Committee of the American Institute of Electrical Engineers upon this unit, as presented in the said paper, be it

RESOLVED, (1) that the committees in joint session recommend to their respective societies the use of the "myriawatt" as unit of thermal or mechanical power, as indicated in the above mentioned paper.

(2) That the two committees also jointly recommend to their respective societies the exclusive use of the "myriawatt" in connection with boilers, producers, turbines and engines and discontinue the use of the term "boiler-horsepower."

(3) That C. O. Mailloux as representing H. G. Stott on the special committee on "Prime Movers" recently appointed by the International Electrotechnical Commission, which committee is scheduled to meet at Zurich, Switzerland, on Jan. 18, 1913, shall be and hereby is requested to bring these joint resolutions formally to the notice of that body in Zurich.

(4) That the two committees jointly recommend that in writings and publications the "myriawatt" and "myriawatt-hour" be abbreviated to mw. and mw.-hr. in conformity with the existing abbreviations kw. and kw.-hr. for kilowatt and kilowatt-hour respectively.

The above resolutions are important for two reasons, namely:

(1) Because this is the first piece of joint standardization work that has been accomplished between two of the national sister engineering societies having their homes in the Engineering Societies Building, of New York City, and it is to be hoped that this may be the starting point for much good joint action of a similar nature between all of the national engineering societies, and (2) The resolutions indicate and recommend a simple and satisfactory method of rating the input and output of turbo-generators, in terms of one and the same unit—the international watt. Instead of rating the output of a turbo-generator in kilowatts, and the input in boiler-horsepower or other heat units as at present, it becomes very convenient to rate the electro output in kilowatts, and the steam input in myriawatts, because the myriawatt is approximately the same as the boiler-horsepower while it is also exactly 10 kw. By this means the long existing incongruity of stating the input and output in different and disconnected units of power will be eliminated.

*Reprinted in Power, Aug. 27, 1912, p. 283.

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Largest Mine Hoist in the World

What is thought to be the largest mine hoist in the world was recently ordered from the Nordberg Manufacturing Co., Milwaukee, Wis., for the Inverness Ry. & Coal Co.'s mine, at Inverness, Cape Breton Island. It is of the Nordberg-Corliss duplex, double-drum type. The cylinders are 34 and 34 by 72 in., and the hoist has two drums, each equipped with Nordberg axial clutch and post brake, enabling independent operation of either drum. The brakes, clutches, reverse and throttles will be operated by an auxiliary engine.

The hoist will pull a 41,000-lb. load up a 10,000-ft. incline, which is 16 deg. at the surface and 35 deg. at the bottom. From the standpoint of rope stress and length of cable, this hoist is thought to be the largest ever

constructed. Hoists with larger cylinders have been built for the copper-mining business, notably the two Nordberg hoists at the Tamarack Mines in Calumet, Mich.

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Locomotive Boiler Accidents

In the first annual report of the Chief Inspector of Locomotive Boilers to the Interstate Commerce Commission, John F. Ensign gives an interesting review of the work carried on during the fiscal year ending June 30, 1912, and the more important requirements of the rules adopted by the commission. A tabular list of the accidents resulting from failure of locomotive boilers and their appurtenances during the year is included and also a number of plates illustrating locomotive-boiler explosions. A classification of the accidents, giving the number of deaths and injuries resulting, appears in the accompanying table.

CLASSIFICATION OF ACCIDENTS AND RESULTING DEATHS AND INJURIES

Nature or Cause of Accidents	Number of Accidents	Killed	Injured
Shell explosion	3	27	41
Crown sheet failures due to low water (no contributory cause found)	69	35	129
Crown sheet failures due to low water, where contributing defects were found	25	19	39
Defective blowoff cocks	23	2	22
Defective washout plugs	11	2	14
Burst water glasses	165	1	168
Burst flues	56	1	62
Steam leaks obscuring engineer's view	1	1	..
Defective steam pipe joints	7	2	7
Defective boiler checks	11	1	11
Burst lubricator glasses	49	..	49
Defective squirt hose and connections	243	..	245
Defective injector steam pipes	31	..	38
Arch tube failures	18	..	23
Injector failures	46	..	47
Defective water-glass cocks and appurtenances	8	..	8
Flue plug failures	7	..	8
Defective studs	12	..	13
Defective lubricators	11	..	12
Defective blower pipes	9	..	10
Defective staybolts	9	..	11
Defective dome caps	2	..	2
Defective draft pipe and brackets	2	..	3
Burst water bars	3	..	4
Defective arch studs	2	..	3
Defective threaded plug (flue sheet)	1	..	1
Defective ash-pan blowers	3	..	3
Defective cap on branch pipe	1	..	1
Defective valves	5	..	5
Defective mud ring	1	..	1
Defective patch bolt	1	..	1
Defective whistle elbow	1	..	1
Defective arch tube plugs	2	..	4
Defective blower throttle bonnets	2	..	2
Burst steam pipe in smoke arch	1	..	1
Defective diaphragm plate	1	..	1
Defective fusible plug	1	..	1
Defective flue pockets	3	..	4
Defective gage cocks	4	..	4
Defective heater pipes	2	..	2
Defective superheater pipe	1	..	1
Defective gasket handhole plate	1	..	1
Defective flue sheet	2	..	2
Total	856	91	1005

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Government Coal Purchases under Specifications

In Bulletin 41 of the Bureau of Mines, George S. Pope explains in general terms the methods that the Government has found most satisfactory for the purchase of a large part of its coal supply, including the consideration of bids, the awarding of contracts, and the analyzing of samples on which the price corrections are based.

For the information of prospective bidders on Government contracts, a list of the coal contracts enforced during the fiscal year ended June 30, 1911, is furnished. General averages of the analyses during the fiscal years, 1908 to 1910, inclusive, are tabulated for the various sizes of anthracite, and also for the several kinds of bituminous coal purchased for Government use; and the results for the fiscal year ended June 30, 1910, are shown in detail by months.

Government contracts are based either on a standard heating value for coal "as received" and a standard percentage of ash "dry coal" or on an ash "dry coal" standard only. The former type of contract is always used for bituminous coal, and is applicable to anthracite as well. The latter type is applicable to anthracite only, but the double standard is becoming more generally used. The specifications for the fiscal year, 1912-13, will differ from the specifications used in preceding years in that the heating value will be expressed on the "dry-coal" basis, provisions being made for variations in the heating value of delivered coal by the establishment of a moisture standard for each contract. They appear in full in Technical Paper 15 of the Bureau of Mines. In the present bulletin the British thermal unit and ash standards are outlined. A chapter on the fuel-inspection laboratory of the Bureau of Mines and methods employed, by Joseph D. Davis, is also included in the Bulletin.

SOCIETY NOTES

Registration on Jan. 7 in the N. A. S. E. evening class at the Lane Technical High School, Chicago, was heavy, 84 being enrolled. Because of this, three divisions were formed, of about 24 members each, to take the same work but to meet on separate nights. This class is the result of an offer by Dr. William Bogan, principal of the school, to furnish a room and an instructor for an engineers' class if sufficient registration were received. The work to be taken up includes power-plant chemistry and the testing of power-plant equipment.

PERSONALS

J. C. Ross has taken charge of the drying department of the B. F. Sturtevant Co., Hyde Park, Mass.

George D. B. Van Tassel has left the Westinghouse Machine Co. to accept a position with the Power Specialty Co., Chicago.

Richard Cary has been appointed sales manager of the lubricant department of the International Acheson Graphite Co., Niagara Falls, N. Y.

H. C. Barber, who was assistant chief engineer of the municipal hydro-electric system in Hamilton, Ont., has been appointed assistant manager of the Toronto Hydro-Electric System.

Charles Merritt has resigned the position as chief engineer of the Phoenix Furniture Co., with which he has been for 21 years, to take charge of the Grand Rapids Municipal pumping and electric light station, in the place of W. M. Gormley, who resigns to return to the American Seating Company.

William Naylor, to celebrate his eightieth birthday, was tendered a complimentary dinner at the Tavern, Chicago, on Jan. 4. Mr. Naylor is highly esteemed by a host of acquaintances and friends and this dinner was the occasion of congratulating him on having rounded out fourscore useful years. He was the engineer of the Marshall Field plant when this now great mercantile business was in its infancy.

C. M. Garland, formerly with the R. D. Wood Co., at one time a member of the faculty of the University of Illinois, is now associated with Woodmansee, Davidson & Sessions, consulting engineers, Chicago, as a combustion engineer. Mr. Garland has had extensive experience in theoretical and practical combustion work during the past ten years, and has specialized in the gasification of fuels and the application of producer and water gas to industrial and power requirements.

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CORRECTION—In the article on "Flat Surface Supported by Stay-bolts," in the Dec. 24 issue, the author's name should have been A. J. Loppin instead of A. J. Toppin; also the charts, Figs. 6 and 7, should have been interchanged.

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The Wheeler Condenser & Engineering Co., Carteret, N. J., announces that it has acquired the American license to build turbo air pumps of the type manufactured in Europe by the Allgemeine Electricitaets Gesellschaft. This air pump is of the rotary water jet type, for motor or steam turbine drive, air being removed from the condenser by ejector action of a series of small water jets and also by positive entrapment of air between successive small slugs of water. A number of these pumps are now under construction at the works of the Wheeler company.